S-480-81

Performance Specification For The NOAA-K, L, M, N, N', & MetOp

Advanced Very High Resolution Radiometer/3

(AVHRR/3)

Flight Models A301, A03, A303, A304, A305, A306, A307, and A308

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Prepared for:
National Aeronautics and Space Administration
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Greenbelt, Maryland

PERFORMANCE SPECIFICATION

FOR THE NOAA-K,L,M,N,N', & METOP

ADVANCED VERY HIGH RESOLUTION RADIOMETER/3

(AVHRR/3)

FLIGHT MODELS A301, A302, A303, A304, A305, A306, A307, AND A308

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FOR THE NOAA-K, L, M, N, N' & METOP1
AVHRR/3 FLIGHT MODELS A301, A302, A303, A304, A305, A306, A307, AND A308

CCR NO.	DATE	MOD #.	DATE	SECTION
1393 (includes 1301, 1403 & 1419)	05/29/96	96	01/24/97	All
1484	06/24/97	102	07/18/97	5.6.4.1
1269B	04/15/97	103	09/09/97	7.1.4.2, 7.1.5.1, 7.1.6, 9.2.3.1, 9.2.3.2
1422	10/18/96	114	07/30/98	5.12
1552A	08/27/98	123	09/04/98	Table 5
1506	11/14/97	122	09/28/98	3.2.7.2
1505, 1511, 1522, 1561, 1568	See Appendix B	125	10/26/98	Appendix B
1413A	11/05/98	124	10/16/98	Title, 1, 6.1.6
1613	02/01/00	157	04/03/00	2.3
1667	04/15/00	162	08/23/00	5.6.4.1f
1751	08/22/00	169	10/02/00	2.5
1644 1648 1649 1653 1685 1682 1570B 1753 1761	09/23/99 09/23/99 09/23/99 11/04/99 02/21/00 04/04/00 07/28/00 07/28/00 09/05/00	172	12/06/00	Appendix B
1618A	06/30/99	177	02/07/01	2.5, 6.1.1, 6.2
1771	11/20/00	196	08/09/01	5.12
1821	06/04/01	205	12/12/01	6.1.7
1852	08/13/01	211	02/28/02	Appendix B
1853	08/13/01	211	02/28/02	Appendix B
1858	09/28/01	211	02/28/01	Appendix B
1840A	08/13/01	212	03/19/02	3.2.7, 3.2.7.1, 3.2.7.2
1861	09/28/01	214	03/18/02	5.16.3
1830A	05/22/02	198	09/13/02	9.1.2, 11.4.4
1903	03/15/02	217	05/21/02	Appendix B
1907	03/13/02	216	05/02/02	Appendix B
1908	03/15/02	217	05/21/02	Appendix B

NAS5-30384, ATTACHMENT B, GSFC-S-480-81, PERFORMANCE SPECIFICATION
FOR THE NOAA-K, L, M, N, N' & METOP1
AVHRR/3 FLIGHT MODELS A301, A302, A303, A304, A305, A306, A307, AND A308

CCR NO.	DATE	MOD #.	DATE	SECTION
1871	01/09/02	235	09/26/02	Table 1, Items 27 and 28
1786B	09/16/02	242	10/16/02	6.1.14
1875	12/12/01	223	12/23/02	Appendix B, Waiver Table
1888	02/04/02	223	12/23/02	Appendix B, Waiver Table
1928	06/21/02	233	09/26/02	Appendix B, Waiver Table
1929	07/22/02	233	9/26/02	Appendix B, Waiver Table
1933	06/20/02	245	12/23/02	Section 10.2
1981	04/02/03	260	07/14/03	Appendix B, Waiver Table
1971R4	06/03/03	261	08/04/03	10.2

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1. SCOPE

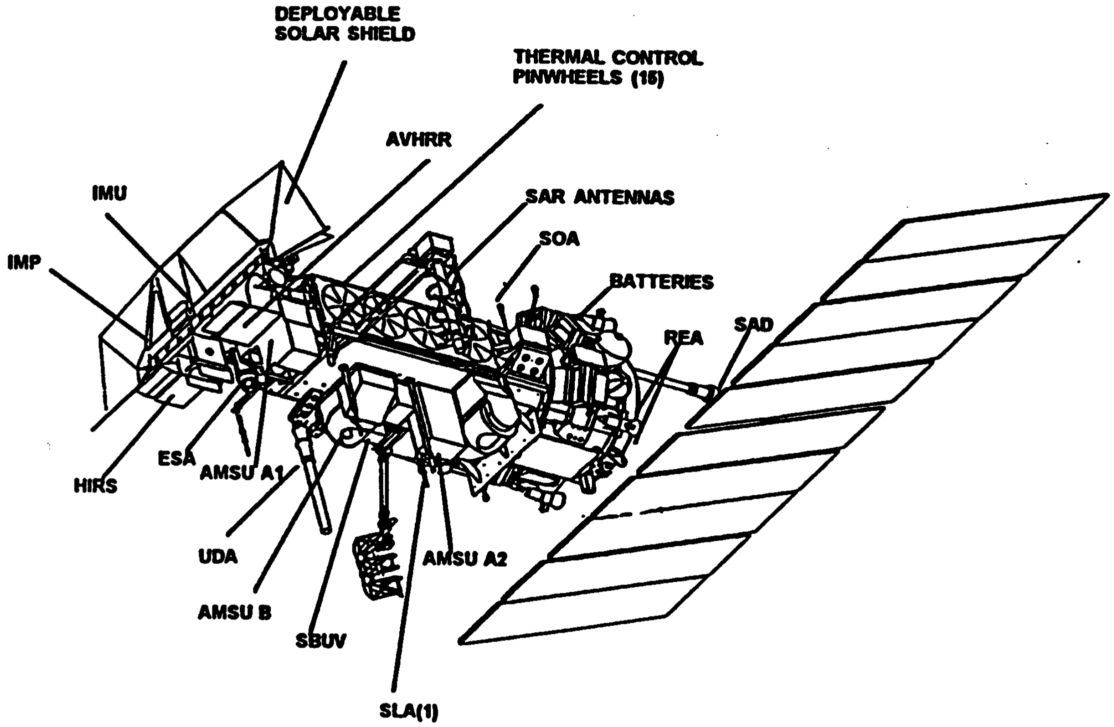
The contractor shall fabricate, test, qualify and deliver seven Advanced Very High Resolution Radiometers/3 (AVHRR/3) and modify and upgrade related Government furnished ground test equipment required for this effort. The design of these instruments shall be based on the existing design of the AVHRR/3. The contractor shall identify problem areas of the existing designs of the systems to be provided under this contract and shall develop and implement new designs using up-to-date and advanced technology in those areas to the extent feasible.

This specification describes the characteristics, specifies the performance and defines the testing and calibration of the Advanced Very High Resolution Radiometer/3 (AVHRR/3) Flight Model instruments S/N A301 through A308 which the contractor shall provide. An artist's concept of the spacecraft is illustrated in Figure 1.

The AVHRR/3 instrument radiative cooler shall have its control point at 105°K with a 10°K margin. To maintain the data interface intact to the spacecraft, channels 3A and 3B shall alternatively share the same data channel on command either from the spacecraft or the ground.

The AVHRR/3 shall be a line scan instrument using a constant rpm scan mirror to scan the earth across the spacecraft orbit track from horizon to horizon. Spacecraft orbital motion provides the forward along-orbital-track dimension to the scan pattern. Scan lines shall start on the anti-sun side of nadir. The scan system shall provide contiguously adjacent scans at the sub-satellite point for all channels. The instrument shall produce high resolution images of the earth and clouds in 6 spectral bands. It is intended to operate channels 1, 2, 4 and 5 all the time and to time share channels 3A and 3B. The radiometer shall have an instantaneous field of view (IFOV) of 1.3 ± 0.2 mr which at the sub-satellite point is 1.09 km (0.59 nmi) for all 6 channels.

Primary calibration for the infrared channels shall be provided by an onboard blackbody target and space.



LEGEND	
AMSU	ADVANCED MICROWAVE SOUNDING UNIT
AVHRR	ADVANCED VERY HIGH RESOLUTION RADIOMETER
ESA	EARTH SENSOR ASSEMBLY
HIRS	HIGH RESOLUTION INFRARED SOUNDER
IMP	INSTRUMENT MOUNTING PLATFORM
IMU	INERTIAL MEASUREMENT UNIT
MHS	MICROWAVE HUMIDITY SOUNDER
REA	REACTION ENGINE ASSEMBLY
SAD	SOLAR ARRAY DRIVE
SAR	SEARCH AND RESCUE
SBUV	SOLAR BACKSCATTER ULTRAVIOLET SOUNDING SPECTRAL RADIOMETER
SOA	S-BAND OMNI ANTENNA
SLA	SEARCH AND RESCUE TRANSMITTING ANTENNA (L BAND)
UDA	ULTRA HIGH FREQUENCY DATA COLLECTION SYSTEM ANTENNA
VRA	VERY HIGH FREQUENCY REALTIME ANTENNA

Figure 1. Artist's Concept of NOAA-K, L, M, N & N' Spacecraft

2. APPLICABLE DOCUMENTS

The issues of the following documents, in effect on the issue date of this specification, shall apply to the fabrication and design effort conducted in accordance with the specification, and shall be considered part of this specification. In the event of conflict between this specification and any referenced document, this specification shall govern.

2.1. GSFC AND GENERAL GOVERNMENT SPECIFICATIONS AND STANDARDS

Federal Standard 209: Clean Room and Work Station Requirements, Controlled Environment.

NHB 5300.4(1A): Reliability Program Provisions for Aeronautical and Space Systems Contractors.

NHB 5300.4(1B): Quality Program Provisions for Aeronautical and Space Systems Contractors.

NHB 5300.4(1C) Inspection System Provision for Aeronautical and Space System Materials, Parts, Components and Service.

NHB 5300.4(3A-2): Requirements for Soldered Electrical Connectors.

NHB 5610.1: Handbook for Preparation of Work Breakdown Structure.

GSFC S-250-P-1C: Contractor Prepared Monthly, Periodic, and Final Reports.

GSFC S-311-P-25A: Specification for Electronic Parts Requirement for TIROS-N.

GSFC S-312-P-1: Specification for Contractor Malfunction Reporting.

GSFC S-320-G-1: General Environment Test Specification for Spacecraft and Components.

GSFC PPL-18: Preferred Parts List.

GSFC X-600-87-11: METSAT Charged Particle Environment Study, dated August 1987

GSFC X-722-77-14: Alignment Mirror Adhesive Evaluation, dated January 1977.

GSFC X-764-71-314: A compilation of Low Outgassing Polymeric Materials Normally Recommended for GSFC Cognizant Spacecraft.

MSFC STD-136: Parts Mounting Design Requirements Printed Circuit Board Assemblies.

S-313-100: Fastener Integrity Requirements, Revision A.

2.2. MILITARY SPECIFICATIONS AND STANDARDS

MIL-STD-130D: Identification Marking for U.S. Government Property.

MIL-STD-461A: Electromagnetic Interference Characteristics, Requirements for.

MIL-STD-462: Electromagnetic Interference Characteristics, Measurement of.

MIL-STD-463: Electromagnetic Interference Technology, Definitions, and System of Units.

DOD-STD-1686: Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (excluding electrically initiated explosive devices), dated May 2, 1980.

MIL-STD-480: Configuration Control, Engineering Changes, Deviations and Waivers.

MIL-D-5480-E: Data Engineering and Technical Reproduction Requirements.

MIL-M-13508: Reflecting Metallic Surface SCOTCH Tape Adhesion Test.

MIL-M-38510: Microcircuits, General Specification for.

2.3. LOCKHEED MARTIN (LM) SPECIFICATIONS

IS-3267415	TIROS-N General Instrument Interface Specification (GIIS), Revision F
IS-20029950	TIROS-N Unique Instrument Interface Specification (UIIS) for the Advanced Very High Resolution Radiometer, Revision F

2.4. ITT DOCUMENT

FINAL REPORT: AVHRR/2 AND HIRS/2I Improvement Study NAS5-29121, Dated July, 1986.

ITT CMP-16603 Configuration Management

2.5. METOP DOCUMENTS

The following documents will be applicable only to the METOP designated instruments.

MO-IC-MMT-AH-0001: AVHRR METOP ICD CCR1618A MOD 177

GSFC S-480-132: Exceptions to the METOP Interface Control Document for the Advanced Very High Resolution Radiometer/3 (AVHRR/3) Flight Models A305, A307, and A308, April 2000.

3. INSTRUCTION TECHNICAL REQUIREMENTS

3.1. TYPICAL ORBITAL PARAMETERS

Orbit altitude - 833±92 km (450±50 nmi) circular

Orbit radius - 7,211 km

Orbit period - 102 minutes

Nodal Regression - 25.4 degrees/orbit w

Sun-synchronous inclination - 98.8 degrees

Nodes - 0600 to 1000, local time, descending node or 1300 to 1800, ascending node

3.1.1 Sun Angle

The AVHRR/3 instrument, with the exception of the radiant cooler and stray energy rejection, shall be designed to operate within specification when exposed to any sun angle from 0° to 80°. The radiant cooler shall operate within specification when exposed to any sun angle from 0° to 68°. The spacecraft will provide shielding for solar angles between 68° to 80° similar to that provided on NOAA-H.

The sun angle is defined as the angle between the satellite-to-sun line and the normal to the orbital plane, with the spacecraft in normal operating orientation.

When the sun is in the instrument's scanned field of view, the instrument is susceptible to stray light energy caused by solar illumination of the instrument's scan mirror, telescope, and/or internal baffles. This stray light energy may be reduced through the use of external and/or internal baffles.

3.2. OPERATIONAL MODES

3.2.1. Launch Phase and Orbital Acquisition Modes

During these modes, the AVHRR/3 will be unpowered except for the scan motor.

3.2.2. Space Radiation Dose Level

The expected radiation dose level shall be as defined in GSFC X-600-87-11 METSAT Charged Particle Environment Study, dated August 1987 and updated by Stassinopoulos to Hilton letter subject: Recalculation of Flux and Dose Values for Non-Equatorial Low-Altitude Radiation Environment, dated 5/11/87.

3.2.3. Lifetime Requirements

3.2.3.1. Storage Period

The AVHRR/3 shall be built to operate within specification following storage in a pressurized dry nitrogen shipping/storage container for a period of up to five years, except for the HgCdTe detector.

3.2.3.2. Storage Temperature

Storage temperature shall be +5° to +25°C.

3.2.3.2.1. Storage Tests

Deleted by Amendment 2 of RFP, 3/10/88.

3.2.3.3. Pre-Launch Operational Lifetime

The AVHRR/3 shall be built to operate within specification for the following cumulative period of time from the beginning of storage to launch:

Pre-Launch Cumulative Operational Lifetime: Four months

3.2.3.4. Orbital Operational Lifetime

The AVHRR/3 shall be built to operate within specification for the following period of time in orbit:

Orbital Operational Lifetime: Three years

3.2.4. Operational AVHRR/3 Baseplate Temperature

The AVHRR/3 instrument shall operate within specification for the following temperature range:

Instrument Operational Baseplate Temperature: +10° to +30°C

3.2.5. Ambient Conditions Operational Limitations Warnings

The Contractor shall identify and document warnings in the instrument Alignment and Calibration Handbook and by letter to the GSFC Technical Officer regarding all sensitive parts, materials and components and operational instrument limitations. An example of such a warning would be that for the maximum recommended time for ambient temperature operation of normally cooled detectors.

3.2.6. Life Tests

Life tests shall be conducted on new motors, motor lubricants or motor bearings introduced into the design of the AVHRR/3 to demonstrate that they will meet the three year four month cumulative lifetime required.

3.2.7. Configuration

The instrument envelope (excluding thermal blankets) shall not exceed dimensions as shown in the preliminary ITT outline drawing 8157456. The dimensions (excluding thermal blankets and sunshield) and weight of the AVHRR/3 including thermal blankets shall not exceed the following: CCR 1840A MOD 212

3.2.7.1. Instrument Dimensions

AVHRR/3 Overall Dimensions = 31.62" x 15.87" x 11.62"
(0.803m x 0.403m x 0.295m) CCR 1840A MOD 212

3.2.7.2. Instrument Weight

AVHRR/3 Total Weight shall not exceed 77.0 pounds. CCR 1840A MOD 212

3.2.8. Power

The spacecraft will provide regulated power at +28.0 V and +10.0 V. In addition, heater power will be supplied from the spacecraft Thermal Control Electronics (TCE) to power the thermal "make-up heater" on the instrument. Dc/dc power conversion in the AVHRR/3 shall provide all voltages which may be required, except for those subsystems operating from the +10.0 V interface bus and from the +28 V pulse load bus.

Converter operation shall be at frequencies which are integral multiples of any frequency synchronized with the scan rate. If more than one dc/dc converter is required, they shall operate at frequencies which will prevent the introduction of undesirable beat frequencies in the passband of the radiometer.

3.2.8.1. Power Conversion EMI

Converter frequencies shall be selected which will place harmonics outside of the Search and Rescue frequency band of 121.5 MHZ$\pm$12.5 kHz.

3.2.8.2. Instrument Power

The total orbital average power usage of the AVHRR/3 shall not exceed the following:

AVHRR/3 Total Average Power = 27 W.

3.2.9. Spacecraft Compatibility

The AVHRR/3 instruments shall be made compatible with the NOAA-K, L, M, N & N spacecraft and shall comply with the following interface specifications:

IS-3267415 - TIROS-N General Instrument Interface Specification. (GIIS)

IS-20029950 - TIROS-N Unique Interface Specification (UIIS) for the Advanced Very High Resolution Radiometer. This interface specification shall take precedence on spacecraft interface requirements over this specification.

3.2.10. Scan System

The AVHRR/3 shall be a scanning radiometer. It shall have a minimum square field of view of 1.3$\pm$0.2 milliradians on a side at the 50 percent power points (sub-satellite point resolution of 1.09 km/0.59 nmi). The instrument shall use a constant rpm scan mirror to scan the earth across the spacecraft orbit track from horizon to horizon. Spacecraft orbital motion will provide the forward along orbital track dimension to the scan pattern. Scan lines shall start on the anti sun side of nadir. The scan system shall provide contiguously adjacent scans at the sub-satellite point for all channels. The scan system shall be in operation during launch.

The spacecraft stabilization will assure that attitude orientation shall be within ±one degree with maximum body rates as follows: 0.072°/sec in pitch, 0.050°/sec in yaw, and 0.016°/sec in roll.

3.2.11. In-Flight Radiometric Calibration

The AVHRR/3 shall provide for the periodic calibration of all infrared channels while in orbit.

3.2.11.1. Channels 1, 2 and 3A Space View

Channels 1,2 and 3A shall view space once per scan mirror revolution. Data obtained through channels 1,2 and 3A during space look shall be part of the digitized video data output of the instrument.

3.2.11.2. In-Flight Radiometric Calibration of Channels 3B, 4 and 5

The in flight calibration data for channels 3B, 4 and 5 shall be obtained automatically during the backscan portion of the scan mirror rotation when the radiometer views radiation from an internal blackbody, whose temperature shall be monitored to an accuracy of better than 0.1°C with a goal of 0.05°C, and when the scan mirror views space. The temperature of the internal blackbody shall be monitored at a minimum of four strategically located points. The temperature gradient measured between any two of the monitoring points shall be less than 0.5°C. A sunshield and/or additional material shall be used to the extent necessary to reduce the temperature gradients and variations in the target to a minimum. The internal blackbody temperature sensor data shall be telemetered to the ground through the housekeeping telemetry system and through insertion into the digitized video signals which are transmitted to the ground.

3.2.12. Commands

The AVHRR/3 instrument shall be provided with means to command it into its various required modes of operation. Telemetry verification of commands received by the instrument shall be provided. Detailed command requirements are described in Table 1.

3.2.13. Clock Signals

The AVHRR/3 shall be provided with 0.9984 MHZ clock signal from the spacecraft for timing purposes. All frequencies used shall be derived from this clock signal.

3.2.14. Telemetry

Telemetry outputs shall be provided to determine the calibration parameters, command verification and operating conditions of the radiometer. Detailed telemetry requirements are described in Tables 2 and 3.

3.2.15. Video Signals

Scene energy shall be focussed on the detectors by the optical system for conversion into electrical signals. These video signals shall be amplified and converted to digital data with an A/D converter. Internal blackbody calibration temperature shall be included in the digitized video data during each scan for channels 3B, 4 and 5. A three level voltage calibration signal shall be injected into the video amplifier channels as close to the detectors as possible on command. In addition, there shall be a continuously stepping 1024 level ramp calibration signal input to the A/D converter during the time that the instrument is in the space clamp period of its scan. The video signal from each channel shall be digitized into a 10 bit word and sent to the spacecraft data processor (which is not part of the radiometer) on parallel buffered output lines.

3.2.16. Scan Line Synchronization

A scan line synchronization pulse shall be generated at a fixed geometric point referenced to the instrument housing by the scan mirror system. All instrument events during each scan shall be referenced to this pulse via counters driven by the spacecraft clock signal.

Table 1

AVHRR/3 Commands

No.	Command	Description
1.	Scan Motor/Telemetry ON	This command shall turn ON the scan motor, scan drive electronics and the first of 3 parallel power switches for housekeeping electronics. Specifically, this command applies power to: a) Electronics sw. regulator b) Motor sw. regulator c) Power converter d) $\pm$15 v regulators e) +5 v motor logic reg. f) Clock receiver g) Motor logic h) Analog telemetry circuits
2.	Scan Motor/Telemetry OFF	This command shall turn OFF the scan motor, scan drive electronics and the first of 3 parallel power switches for housekeeping telemetry.
3.	Electronics/Telemetry ON	This command shall turn ON the radiometer electronics (except the scan drive eletronics) for all channels in the ENABLE mode, and the second of 3 parallel power switches for housekeeping telemetry. This command applies power to: a) Electronics sw. regulator b) Power converter c) $\pm$15 v regulators d) +5 v motor logic regulator e) +5 v electronics regulator f) Analog telemetry circuits g) A/D converter h) Scan timing logic I) Clock receiver j) Motor logic
4.	Electronics/Telemetry OFF	This command shall turn OFF the radiometer electronics and the second of 3 parallel power switches for housekeeping telemetry.
5.	Channel 1 (0.63u) Enable	If (3) Electronics/Telemetry ON has been executed, this command applies power to: a) Ch #1 Preamplifier b) Ch #1 Postamplifier
6.	Channel 1 (0.63u) Disable	Removes power from: a) Ch #1 Preamplifier b) Ch #1 Postamplifier

Table 1 (Continued)

AVHRR/3 Commands

No.	Command	Description
7.	Channel 2 (0.86u) Enable	If (3) Electronics/Telemetry ON has been executed, this command applies power to: a) Ch #2 Preamplifier b) Ch #2 Postamplifier
8.	Channel 2 (0.86u) Disable	Removes power from: a) Ch #2 Preamplifier b) Ch #2 Postamplifier
9.	Channel 4 (10.8u) Enable	If (3) Electronics/Telemetry ON has been executed, this command applies power to: a) Ch #4 Preamplifier b) Ch #4 Postamplifier
10.	Channel 4 (10.8u) Disable	Removes power from: a) Ch #4 Preamplifier b) Ch #4 Postamplifier
11.	Channel 3B (3.7u) Enable	If (3) Electronics/Telemetry ON has been executed, this command applies power to: a) Ch #3B Preamplifier b) Ch #3B Postamplifier
12.	Channel 3B (3.7u) Disable	Removes power from: a) Ch #3B Preamplifier b) Ch #3B Postamplifier
13.	Cooler Heat ON	If Electronics ON, Motor ON or Telemetry ON has been executed, the command applies power to: a) Radiator Decontamination Heater b) Patch Decontamination Heater
14.	Cooler Heat OFF	Removes power from: a) Radiator Decontamination Heater b) Patch Decontamination Heater

u = micron

Table 1 (Continued)

AVHRR/3 Commands

No.	Command	Description
15.	Telemetry Locked ON	This command shall turn on the third of 3 parallel power switches for Housekeeping Telemetry, thereby locking the telemetry ON independent of Commands 1 through 4. This command applies power to: a) Electronics sw. regulator b) Power converter c) $\pm$15 v regulators d) +5 v motor logic regulator e) Analog telemetry circuits f) Clock receiver g) Motor logic h) Patch temp. control
16.	Telemetry NOT Locked ON	This command shall turn off the third of 3 parallel power switches for Housekeeping Telemetry thereby returning the telemetry to the control of Commands 1 through 4.
17.	Earth Shield Deploy	Applies Power to: a) Earth Shield Circuitry
18.	Earth Shield Disable	Removes Power from: a) Earth Shield Circuitry
19.	Patch Control ON	If Telemetry ON has been executed, this command applies controlled heat to: a) Patch
20.	Patch Control OFF	Removes heat from patch.
21.	Channel 5 (12u) Enable	If (3) Electronics/Telemetry ON has been executed, this command applies power to: a) Ch #5 Preamplifier b) Ch #5 Postamplifier
22.	Channel 5 (12u) Disable	Removes power from: a) Ch #5 Preamplifier b) Ch #5 Postamplifier

Table 1 (Continued)

AVHRR/3 Commands

No.	Command	Description
23.	Voltage Calibrate ON	If Electronics ON and Motor ON have been executed, then this command: a) Deactivates IR & Visible detectors b) Provides simulated earth scene & backscan video for all enabled channels.
24.	Voltage Calibrate OFF	If Electronics ON and Motor ON have been executed, then this command: a) Activates IR & Visible detectors. b) Deactivates simulated earth scene & backscan video.
25.	Channel 3A (1.6u) Enable	If (3) Electronics/Telemetry ON has been executed, this command applies power to: a) Ch #3A Preamplifier b) Ch #3A Postamplifier
26.	Channel 3A (1.6u) Disable	Removes power from: a) Ch #3A Preamplifier b) Ch #3A Postamplifier
27.	Scan Motor High Mode	If “Motor ON” has been executed, then this command: a) For A301, A302, and A304 – Sets motor sw. regulator voltage to HIGH LEVEL. b) For A303, A305, and up – Has no effect on Instrument operation.
28.	Scan Motor Low Mode	If “Motor ON” has been executed, then this command: a) For A301, A302, and A304 – Sets motor sw. regulator voltage to LOW LEVEL. b) For A303, A305, and up- Has no effect on Instrument operation.
29.	Ch 3A Select (1.6u)	This command selects Channel 3A output for transmission to the ground.
30.	Ch 3B Select (3.7u)	This command selects Channel 3B output for transmission to the ground.

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Table 2

AVHRR/3 Digital B Telemetry

Command Verification Telemetry

Telemetry Channel	Telemetry Point	Status Indicated Logic True (0 volts)	Logic False (+5 volts)
1	Scan Motor/Telemetry	ON	OFF
2	Electronics/Telemetry	ON	OFF
3	Channel 1 (0.63u)	Enable	Disable
4	Channel 2 (0.86u)	Enable	Disable
5	Channel 4 (10.8u)	Enable	Disable
6	Channel 3B (3.7u)	Enable	Disable
7	Voltage Calibrate	ON	OFF
8	Channel 3A (1.6u)	Enable	Disable
9	Cooler Heat	ON	OFF
10	Scan Motor Mode	High	Low
11	Housekeeping Telemetry	Locked On	Not Locked On
12	Earth Shield	Deploy	Disable
13	Patch Control	ON	OFF
14	Channel 5 (12u)	Enable	Disable
15	Channel 3A/3B Output Select	3A	3B

Table 3

AVHRR/3 Analog Telemetry

No.	Telemetry Point	Description
1.	Patch Temperature	This telemetry point measures the output from a platinum temperature thermometer located on the radiant cooler patch which contains the IR detectors over a limited temperature range.
2.	Patch Temperature Extended	This telemetry point measures the output from the same platinum temperature themometer as above located on the radian cooler patch which contains the IR detectors over the complete operating temperature range.
3.	Patch Power	This telemetry point measures the power being applied to the control heater on the radiant cooler patch.
4.	Radiator Temperature	This telemetry point measures the output from the platinum temperature thermometer located on the first stage of the radiant cooler.
5.- 8.	Blackbody No. 1,2,3&4	These telemetry points measure the outputs of the platinum temperature thermometers No.'s 1 through 4, respectively, located on the black body calibration target.
9.	Electronics Current	This telemetry point measures the DC current load on the +28 volt bus (pins 1 and 2 on J3). This is directly proportional to the DC current into the power converters for the remaining electronics not including the motor power supply.
10.	Motor Current	This telemetry point measures the DC current load on the +28 volt motor bus (pins 3 and 4 on J3). This is directly proportional to the DC current into the scan motor power supply.
11.	Earth Shield Position	This telemetry point indicates the position of the radiant cooler earth shield.
12.	Electronics Temperature	This telemetry point measures the output of the thermistor located inside the electronics box.
13.	Cooler Housing Temperature	This telemetry point measures the output from a thermistor located on the radiant cooler housing.
14.	Baseplate Temperature	This telemetry point measures the output of the thermistor located on the baseplate

Table 3 (Continued)

AVHRR/3 Analog Telemetry

No.	Telemetry Point	Description
15.	Motor housing Temperature	This telemetry point measures the output from a thermistor located on the scan motor housing.
16.	A/D Converter Temperature	This telemetry point measures the output of a thermistor located inside the A/D converter at the point of maximum sensitivity to heat.
17.	Detector Bias V Ch #4	This telemetry point measures a voltage directly proportional to the regulated -12 vdc which supplies the Ch #4 (10.8u) I detector bias current.
18.	Blackbody Ch #4 Output	This telemetry point measures the output of a sample and hold circuit which samples the IR Ch #4 (10.8u) analog data signal once each scan line when viewing the blackbody calibration target.
19.	Blackbody Ch #3B Output	This telemetry point measures the output of a sample and hold circuit which samples the IR Ch #3B (3.7u) analog data signal once each scan line when viewing the blackbody calibration target.
20.	Reference Voltage	This telemetry point measures a DC voltage proportional to the +6.4 volt reference voltage source in the electronics.
21.	Detector Bias V Ch # 5	This telemetry point measures a voltage directly proportional to the regulated –12 vdc which supplies the Ch #5 (12u) IR detector bias current.
22.	Blackbody Ch #5 Output	This telemetry point measures the output of a sample and hold circuit which samples the IR Ch #5 (12u) analog data signal one each scan line when viewing the blackbody calibration target.

4. INSTRUMENT PERFORMANCE REQUIREMENTS

4.1. INSTRUMENT CHANNELS

4.1.1. Channel Characteristics

The AVHRR/3 shall measure scene radiances in 6 spectral bands. The channels used to measure these spectral bands shall have the characteristics specified in Table 4.

4.1.2. Channels 1 and 2 Spectral Symmetry

The spectral symmetry and uniformity shall be improved as described in ITT AVHRR/2 and HIRS/2I Improvement Study. Eliminate channel 1 out of band energy at 0.92 micrometers.

4.1.3. Channels 1, 2 and 3A Dual Gain Slopes

Dual gain slopes shall be incorporated in channels 1, 2 and 3A as specified in Table 4.

4.1.4. Channels 3B, 4 and 5 Maximum Scene Temperature

The channel 3B, 4 and 5 gains shall be set in a manner that will permit the instrument to respond to energy from a maximum scene temperature of 335°K.

4.1.5. Channel 2 Spectral Bandpass Selection

The spectral bandpass of channel 2 shall be that specified in the Table 4.

4.1.6. Channel 3A and 3B Selection

To keep this instrument compatible with the existing spacecraft and ground data handling system, only 5 of the 6 channels may be read out at any time. Accordingly, channels 3A and 3B will alternatively share the same data output channel. Ground and spacecraft commands shall be provided to select either the channel 3A (1.6 micrometer) or channel 3B (3.7 micrometer) data output for transmission and for storage on-board the spacecraft.

4.1.7. Spatial Resolution

The spatial resolution of all channels shall be adequate to provide peak-to-peak modulation transfer of at least 0.3 for simulated sub-satellite target sizes of 1.09 km (0.59 nmi). The target contrast ratio shall be 30:1 or higher.

The Modulation Transfer Function (square wave MTF) of the output of the radiometer for all channels shall be equal to or better than the following:

Sub-satellite target sizes	MTF
4.36 km (2.36 nmi)	1.0

2.18 km (1.18 nmi)	0.75
1.64 km (0.88 nmi)	0.50
1.09 km (0.59 nmi)	0.30

4.2. DYNAMIC RANGE

The AVHRR/3 channels 1, 2, and 3A shall measure scene radiances from 0 to 100% albedo assuming normal solar incidence and a diffusely reflecting surface. Channels 3B, 4 and 5 shall measure scene radiances over the temperature range of 180° to 335°K.

4.3. NOISE EQUIVALENT TEMPERATURE DIFFERENCE (NEDT)

The AVHRR/3 shall meet the required NEDT specified in Table 4.

Table 4

AVHRR/3 Channel Characteristics

CH No.	(50% Points) Max Spectral Band Micrometers	NEDT S/N	Res. SSP km	Albedo Range %	Counts Range
1	0.58 - 0.68	9:1 @ 0.5% Albedo	1.09	0 - 25 26 - 100	0 - 500 501 - 1000
2	0.725 - 1.00	9:1 @ 0.5% Albedo	1.09	0 - 25 26 - 100	0 - 500 501 - 1000
3A	1.58 - 1.64	20:1 @ 0.5% Albedo	1.09	0 - 12.5 12.6 - 100	0 - 500 501 - 1000
				Max Scene Temp ^{0}K	
3B	3.55 - 3.93	0.12 300K Scene	1.09	335	
4	10.30-11.30	0.12 300K Scene	1.09	335	
5	11.50-12.50	0.12 300K Scene	1.09	335	

SSP = Sub-satellite Point
TMP = Temperature
NEDT = Noise Equivalent Temperature Difference

4.3.1. Measurement of NEDT and S/N

The standard deviation of 50 or more samples of radiometric data taken from an external reference target or from the internal calibration targets, for any spectral band, shall be equal to or less than the required NEDT or S/N for that band.

NEDT (300^0K) = (Standard deviation of counts) * (slope), where slope is the calibration slope (radiance per count) divided by dR/dT at 300^0K, where R is radiance in the channel of interest and T is temperature. (With this prescription, the NEDT at 300^0K can be determined from a target at any temperature. The target does not have to be at 300^0K.)

At each baseplate temperature, three NEDTs will be used to judge if the noise specification is met. They are (1) the average of the NEDTs from each of 17 space looks associated with the temperature plateaus of the external target, (2) the average of the NEDTs from each of the 17 Internal Calibration Target (ICT) measurement associated with the same 17 plateaus, and (3) the average of the 17 NEDTs from the External Calibration Target (ECT) at each of the 17 plateaus. Each of these three NEDTs must be less than or equal to 0.12^0K for this specification to be met.

4.4. ABSOLUTE ACCURACY

The reference sources used as targets for preflight calibration shall have temperature sensors calibrated to not less than secondary standards traceable to the NIST.

The spectral output radiance of the shortwave reference target shall be measured to the accuracy of secondary NBS standards over the range of wavelengths sensed by channels 1, 2 and 3A within several months before or after the preflight calibration of each instrument. To scale the radiant output of the sphere to an equivalent albedo if illuminated by the sun, the extraterrestrial spectral solar irradiance values of Neckel and Labs (1984) shall be used.

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5. ELECTRICAL REQUIREMENTS

5.1. GENERAL

All specified characteristics shall be within tolerance over the specified lifetime of the instruments despite the combined effects of signal, impedance, and power supply variations (within specified tolerances, but taken as worst case values), radiation, degradation, and environmental extremes. The radiometer shall be designed to withstand a continuous over voltage on power busses without damage and to return to normal operation when the over voltage condition is removed.

Video output signals of 5 of the 6 channels shall be processed through the A/D converter into 10 bit digital words which shall be shifted out in parallel to the MIRP. The video signals and certain analog temperature monitoring signals shall be sampled at regular intervals and merged. The scan program and other functions shall be synchronously timed with the data processing and the spacecraft clock. Certain command functions, temperatures and status monitoring data must be supplied to the TIP.

5.2. PRINTED CIRCUITS

All new or changed electronic circuit designs and their printed circuit board layouts shall be optimized for reliability and shall employ good engineering practices. The Contractor shall document this effort in a separate section of the Technical Description Document due at the end of his design phase.

All new or changed AVHRR/3 instrument and ground support equipment circuits shall be entered into a Computer Aided Design/Computer Aided Engineering (CAD/CAE) system. The Contractor shall demonstrate proof-of-operation of these circuits on the CAD/CAE system prior to the fabrication of any hardware. The Contractor shall appropriately document the proof-of-operation demonstrations in written reports. From time-to-time, the Contractor will be called upon to conduct, using CAD/CAE, specific circuit performance analyses, including optimization, parametric and failure mode analyses.

5.3. ELECTRONIC PARTS

Parts previously approved on NAS 5-26771 (NOAA-H, I & J program) are approved for use on this program. Where new or different parts are necessary or desirable they shall be selected from PPL-18, Preferred Parts List, Grade 1 Parts, if possible. Otherwise approval for use shall be by Nonstandard Part Approval Request (NSPAR). Previously approved non-grade 1 parts, which were not on a Preferred Parts List (PPL), shall be identified only, no new NSPAR for them will be required.

5.4. INSTRUMENT INPUT AND OUTPUT INTERFACE CIRCUITS

Instrument interface circuits, including those for command, telemetry, clock, data strobe and digital data, shall be compatible with the spacecraft interface circuits. See the TIROS-N GIIS and UIIS for additional information.

5.5. FAIL-SAFE INTERFACE CIRCUIT DESIGN

All digital and analog telemetry outputs shall have the following fail-safe provisions:

1. Overrange Limits: Under failure conditions in the radiometer, telemetry outputs shall not exceed the overrange limits -0.70 to +6.0 volts. If any type of failure in the radiometer could cause the outputs to exceed these limits, then protective clamping shall be provided.

2. Short Circuit Protection: A short circuit to ground on any telemetry output shall not cause any malfunction in the radiometer.

5.6. ANALOG ELECTRONICS

5.6.1. Electronic Calibration

A system for calibrating and/or checking the linearity of the electronics shall be incorporated; for example, an electronic stair case can be inserted at the earliest possible stage in the electronic chain.

5.6.2. Resolution

The resolution of the analog signal for each channel shall be equal to or less than ±6.25 mV (0.1% full scale).

5.6.3. Channels 1, 2 and 3A Video Characteristics

The characteristics of the video signals from channels 1, 2 and 3A before digitization shall be as follows:

5.6.3.1. Channels 1, 2 and 3A Signal Output

a. The signal amplitude shall be from 0 to 6.4 volts. These channels shall be provided with dual slope amplifiers as specified in Table 4. The gain shall be set so that the maximum radiance input corresponds to +6.05±0.15 volts in channels 1 & 2, and +6.00±0.20 volts for channel 3A. The gain settings shall allow for an adjustable maximum radiance input and dual gain slope intercept point with a minimum of disassembly of the instrument. The gains shall remain constant after setting to insure the accuracy requirements.

b. The maximum radiance input shall be 100 percent albedo assuming normal solar incidence and a diffusely reflecting surface. The signals from the radiometer when viewing a calibration source representing the maximum radiance for the chosen gain setting shall be measured when the radiometer is maintained at its nominal temperature. When the radiometer baseplate is varied over a 10° to 30°C temperature range the signal obtained when viewing a 100% albedo source shall not vary more than ±100 mV for channel 1 and ±120 mV for channels 2 and 3A; when viewing a 25% albedo source channel 1 shall not vary more than ±25 mV and channel 2 shall not vary more than ±30 mV; and when viewing 12.5% albedo channel 3A shall not vary more than ±15 mV.

c. The contractor shall define the calibration procedure for each channel.

d. The dc level shall be set at $+0.25\pm0.05$ volts and reestablished to the set voltage to within 1 NEDT once each scan line during a period of minimum radiance input (radiometer scanning deep space).

e. The signal droop shall be less than 0.1% of the full signal amplitude during one complete scan (one-sixth second).

f. The drift from scan line to scan line shall not exceed the rms noise voltage for each of the channels.

g. The presampling filter shall be designed to optimize the total radiometer performance. It is expected that the analog video shall be sampled at a maximum rate of 40K Samples/Sec/Channel.

h. Scanning a step function input in radiance shall produce a maximum overshoot of 2% of the final amplitude with less than one cycle of the ringing frequency. The rise time shall be consistent with the presampling filter bandwidth chosen from considerations in section g. above.

5.6.4. Channels 3B, 4 and 5 Video Characteristics

The characteristics of the video signals from channels 3B, 4 and 5 before digitization shall be as follows:

5.6.4.1. Channels 3B, 4 and 5 Signal Outputs

a. Positive type analog signal with the dc level restored each scan line when the radiometer views deep space.

b. The signal amplitude for channels 3B, 4 and 5 shall be from 0 to 6.4 volts. The gain shall be set so that $+0.3\pm0.1$ volts corresponds to a target temperature of $335^{\circ}K\pm0.1^{\circ}K$. The gain setting shall allow for an adjustable maximum radiance input by changing a fixed resistor in an amplifier with a minimum of disassembly of the instrument. The signals from the radiometer when viewing a $335^{\circ}K$ calibration source shall be measured when the radiometer baseplate temperature is maintained at its nominal temperature. The signal obtained when viewing the same source shall not vary more than ±100 mV when the radiometer baseplate temperature is varied from 10° to 20° for channels 3B, 4 and 5.

c. The dc level shall be set at 6.2 ± 0.05 volts and reestablished to the set voltage to within 1 NEDT once each scan line for channels 3B, 4 and 5 and while viewing deep space.

d. The drift from scan line to scan line shall not exceed one NEDT rms for channels 3B, 4 and 5, e.g., the drift in channel 3B shall not exceed $0.12^{\circ}K$ rms when viewing a scene of $300^{\circ}K$.

e. The signal droop shall be less than 0.1% of the full signal amplitude during one complete scan (one-sixth second).

f. The presampling filter shall be designed to optimize the total radiometer performance. It is expected that the analog video shall be sampled at a maximum rate of 40K Samples/Sec/Channel.

The ratio of the maximum deviation of the mean of each row of space and ICT samples to the in line standard deviation calculated on a bland scene shall be less than 3.5 when calculated as per the following equations:

$$\frac{\mu_{ICT}^{Max} - \mu_{ICT}^{Min}}{AVG(\sigma_{scene::row})} < 3.5 \qquad \frac{\mu_{Space}^{Max} - \mu_{Space}^{Min}}{AVG(\sigma_{scene::row})} < 3.5$$

As an alternative calculation for when $AVG(\sigma_{scene::row})$ is less than 0.3 counts, the following relations shall be used:

$$\mu_{ICT}^{Max} - \mu_{ICT}^{Min} < 1.1 \qquad \mu_{Space}^{Max} - \mu_{Space}^{Min} < 1.1$$

Definitions:

ICT = Internal Cal target (Blackbody target on the instrument)

ECT = External Cal target (chamber target simulating the earth scene)

$\mu_{Max,\ ICT}$ = the maximum mean ICT count value from a set of 360 means (each scan line produces one mean). Each mean is the average of 10 ICT samples per scan line. 360 scan lines of data are collected which equals one minute of data.

$\mu_{Min,\ ICT}$ = the minimum mean ICT count value from a set of 360 means (each scan line produces one mean). Each mean is the average of 10 ICT samples per scan line. 360 scan lines of data are collected which equals one minute of data.

$\mu_{Max,\ Space}$ = the maximum mean Space count value from a set of 360 means (each scan line produces one mean). Each mean is the average of 10 Space samples per scan line. 360 scan lines of data are collected which equals one minute of data.

$\mu_{Min,\ Space}$ = the minimum mean Space count value from a set of 360 means (each scan line produces one mean). Each mean is the average of 10 Space samples per scan line. 360 scan lines of data are collected which equals one minute of data.

$AVG(\sigma_{scene::row})$ = at a given ECT temperature, the RMS value of 360 standard deviations. Each of the 360 standard deviations is the standard deviation of 10 ECT samples per scan line. 360 scan lines of data are collected which equals one minute of data. If data is available at more than one ECT temperature, the RMS values at each temperature can be RMS'ed together to produce a single number.

g. Scanning a step function input in radiance shall produce a maximum overshoot of 2% of the final amplitude with less than one cycle of the ringing frequency. The rise time shall be consistent with the presampling filter bandwidth chosen from considerations in section f. above.

5.6.5. Voltage Calibration Signals

There shall be two voltage calibration signals.

5.6.5.1. Ramp Calibration Signal

The ramp calibration signal shall consist of the output of the D/A converter which increases one step per revolution of the radiometer scanning system. A ramp shall be generated every 1024 scans of the radiometer. The ramp voltage shall vary from -0.025 to +6.475 volts in 1023 steps of 0.00635 volt, and shall have a precision of 10 bits.

The A/D converter has a range from 0 to +6.39375 volts in 1023 steps of 0.00625 volts. As a result, the nominal ramp calibration output will skip a step approximately once every 62 steps and the low voltage end of the ramp (beginning of ramp for channels 1, 2 and 3A, and end of ramp for channels 3B, 4 and 5) will have approximately 5 "0" values, while the high voltage end of the ramp will have approximately 14 "1023" values.

The ramp calibration signal shall be added to the video signal train of all channels during the space clamp portion of scan mirror rotation. It provides a continuous in-orbit means to voltage calibrate all channels through their preamplifiers over their full dynamic range.

The short term stability (several hours) of the ramp calibration signal shall be within 2 its least significant bit and the long term stability at full scale shall be within 2 bits. The output steps shall be accurate to within 2 the step size assuming a linear interpolation between zero and full scale.

Channels 1,2, and 3a shall increment linearly with the scan count, except as previously noted, until the dual gain break point of 500 counts is reached. The range of ramp calibration counts shall be from 501 to 679 for scan lines 501 to 1023 in Channels 1 and 2 and 501 to 577 for the same scan line count in Channel 3A.

Channels 3B, 4, and 5 ramp values shall increment linearly with scan line count, except as previously noted, and shall have approximately 14 6.39375 volt, 0 count end-of-ramp values.

5.6.5.2. Simulated Earth Calibration Signal

The simulated Earth calibration signal shall provide three voltage levels in a cyclic pattern on successive scan lines for all channels. This shall provide a consecutively increasing amplitude 3 point voltage calibration check for each channel. The signal shall be substituted for the detector outputs upon command. It is intended for use primarily for integration and pre-launch checkout of the instrument.

The voltage calibration signal shall be similar to a full scan line of real output containing data from the space scan, earth scan and internal blackbody target portions of scan mirror rotation and shall be produced in synchronism with the radiometer line synchronization pulse.

5.6.6. Channels 3B, 4 and 5 Internal Blackbody Calibration

5.6.6.1. Target

An internal passive blackbody target shall be provided which will fill the field of view of the infrared channels and provide them with a warm temperature calibration point every scan line when it is viewed during the backscan portion of the scan mirror rotation. The surface of this target area shall be designed to simulate a blackbody radiator and the radiation characteristics shall be determined during the program.

5.6.6.2. Instrument Measurement of Internal Target

The average temperature of the internal blackbody target as computed by averaging the four platinum resistor sensor temperature outputs shall be measured by each infrared channel of the instrument to a precision of 1 NEDT of 0.12°K at a scene temperature of 300°K.

5.7. INSTRUMENT OUTPUT SIGNALS

5.7.1. General

The output data signals supplied by the instrument to the spacecraft fall into three categories - outputs to the Manipulated Information Rate Processor (MIRP), Digital "B" Telemetry and Analog Telemetry. The specific signals supplied by the AVHRR are detailed below.

5.7.2. Instrument Outputs to the MIRP

The analog video signals from each of the six channels shall be digitized in the instrument to a ten bit word and brought out of the instrument as a 10 bit parallel digital output. Upon receipt of a Data Sample Pulse from the MIRP, the digital words (one for each radiometric channel) shall be transferred sequentially to the MIRP.

The analog video signal from channels 3B, 4 and 5 shall be sampled each scan line while the radiometer is viewing the IR calibration target and space, digitized and merged with the output data to the MIRP. Ten samples of calibration target data and ten samples of space data shall be taken each scan line.

The data in each ten bit word shall be transferred by parallel readout of the 10-bit word through ten output data lines.

5.7.2.1. Content

The information content of each data channel shall be as follows:

	Chan. 1	Chan. 2	Chan. 3A	Chan. 3B	Chan. 4	Chan. 5
Deep Space (Clamp)	x	x	x	x	x	x
Ramp Calibration Signal	x	x	x	x	x	x
Earth Scene (Visible)	x	x	x			
Earth Scene (Infrared)				x	x	x
Internal Blackbody PRT Temps.				x	x	x
Cooler Patch Temperature				x	x	x
Internal Blackbody Infrared Data				x	x	x

5.7.2.2. Digitization

10-bit words

5.7.2.3. Output

Parallel readout, 10 bits

Transfer of AVHRR digitized data shall be accomplished by 10 parallel lines representing parallel word transfer.

At 5t$\pm$300 nanoseconds ($t=1/(0.9984 \times 10^6)$ sec) after each sample time (the negative going edge of the clock which is coincident with the high or true state of the sample pulse) the AVHRR shall transfer parallel digitized channel 1 data to an output register and hold it there for 5t$\pm$300 nanoseconds. Data from the remaining AVHRR channels shall be successively transferred into the output register as follows:

Channel 2 transfer time shall be 10t$\pm$300 nanoseconds after sample time, data shall be held for 5t$\pm$300 nanoseconds. Channel 3 (A or B) transfer time is 15t$\pm$300 nanoseconds, data is held for 5t$\pm$300 nanoseconds. Channel 4 transfer time is 20t$\pm$300 nanoseconds, data is held for 5t$\pm$300 nanoseconds. Channel 5 transfer time is 25t$\pm$300 nanoseconds, data is held for 5t minimum, 10t maximum $\pm$300 nanoseconds. Transfer of data from the AVHRR output register to the spacecraft processor shall occur 0.5t to 4.5t after the start of each channel output time interval. See Figure 2.

5.7.2.4. Interface Circuit

A standard TTL gate, type SN5440, shall be used as the driver for each parallel output line. These lines shall not be damaged by a short to the power bus or ground.

5.7.2.5. Pulse Level

a. A data "1" shall be +2.40 to +5.25 volts

b. A data "0" shall be 0.0 to +0.4 volts

5.7.2.6. Data Word Rate to MIRP

199,680 words per second. (Five 10-bit AVHRR data words per sample pulse x 39,936 sample pulses per second) Time between sample pulses = 25t. Each sample pulse shall be phased so that a negative going edge of the 0.9984 MHZ clock will occur during the high or true state of the sample pulse.

5.7.2.7. Bit Position

1. The MSB of the Radiometric data shall be located on the data line #1 for each channel.

2. The LSB of Radiometric Data shall be located on data line #10 for each channel.

5.7.3. AVHRR/3 Digital Data Output

AVHRR/3 output digital data is sampled by the MIRP as follows:

AVHRR/3 Output Information	Time from Line Sync Pulse (ms)	Number of Samples
Detector: Space View	2.529	10
Electronic Ramp Cal.	3.756	1
Detector: Earth View	8.614	2048
TLM: IR Blackbody Temp.	65.780	1
TLM: Cooler Patch Temp.	66.006	1
Detector: IR Blackbody Target	118.064	10

5.7.4. Scan Line Synchronization Pulse

A Scan Line Synchronization Pulse shall be sent to the MIRP at the beginning of each scan mirror scan. The synchronization pulse shall be generated before the horizon on the anti-sun side of nadir as shown in Figure 3. The characteristics of this pulse shall be as follows:

1. Duration: 100 microseconds.

2. Repetition Rate: 6 pps (Scan Mirror rotation = 360 rpm).

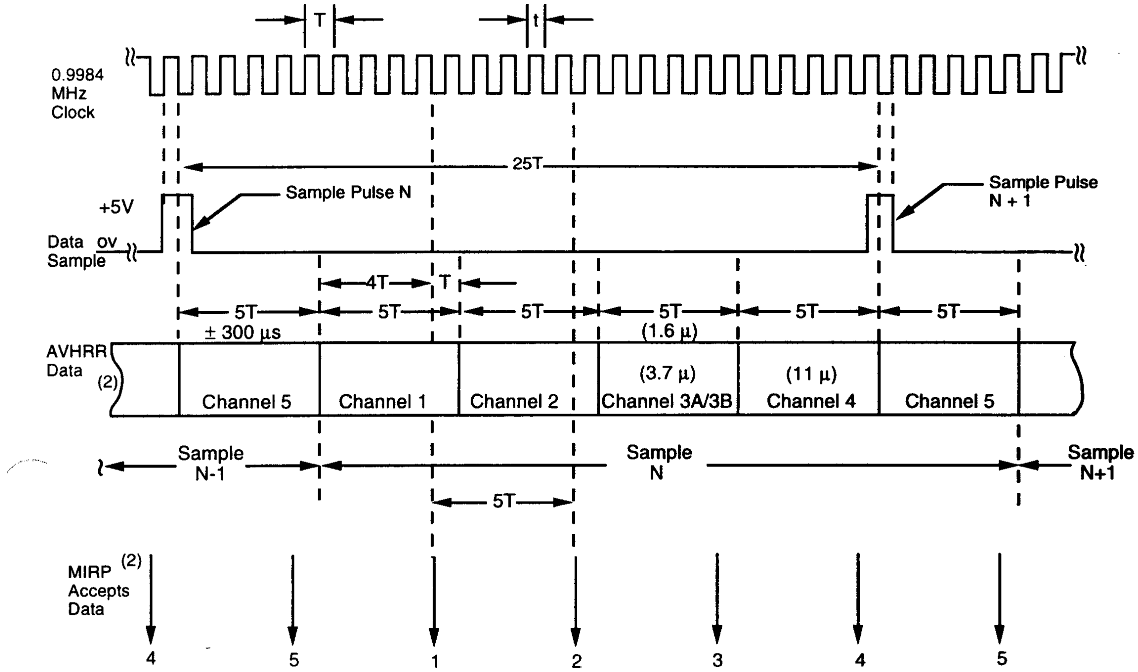
3. Noise spikes: Less than 1/4 signal amplitude

4. Instrument Interface Circuit: Standard TTL gate, type SN5440. This logic element shall be powered by +5 volts from the AVHRR power converter and referenced to Signal Ground. See Figure 4.

5. Pulse Level: The scan line synchronization pulse output shall normally be at ground levlel (0.0 to +0.4 V). The sync pulse output shall go to the +5 volt level (+2.40 to +5.25 V) for the 100 microsecond duration of each sync pulse.

6. Shielding: The shield of the sync pulse line shall be tied to the AVHRR chassis ground.

7. Timing: The pulse shall be generated on the anti-sun side of nadir before the scan line crosses the horizon. It shall be generated within 10 arc minutes of the same line synchronization pulse position as generated on previous AVHRR's.



NOTES:

1) $T = \frac{1}{0.9984 \times 10^{+6}}$ sec.
2) AVHRR Channel identification shown (as opposed to MIRP ID's).
3) Sample input is normally at ground level (0.0* to +0.4V).
4) Sample goes to +5V level (+4.0V to 5.25V) for duration of each sample pulse.
5) Channel 5 is a repeat of Channel 3 for AVHRR/1 only.
6) $0.4\,T \leq t \leq 0.6\,T$.

*This could go to -0.01V at the AVHRR if there is 90 mA flowing in the AVHRR Signal Ground.

Figure 2. MIRP - AVHRR/3 Interface Timing

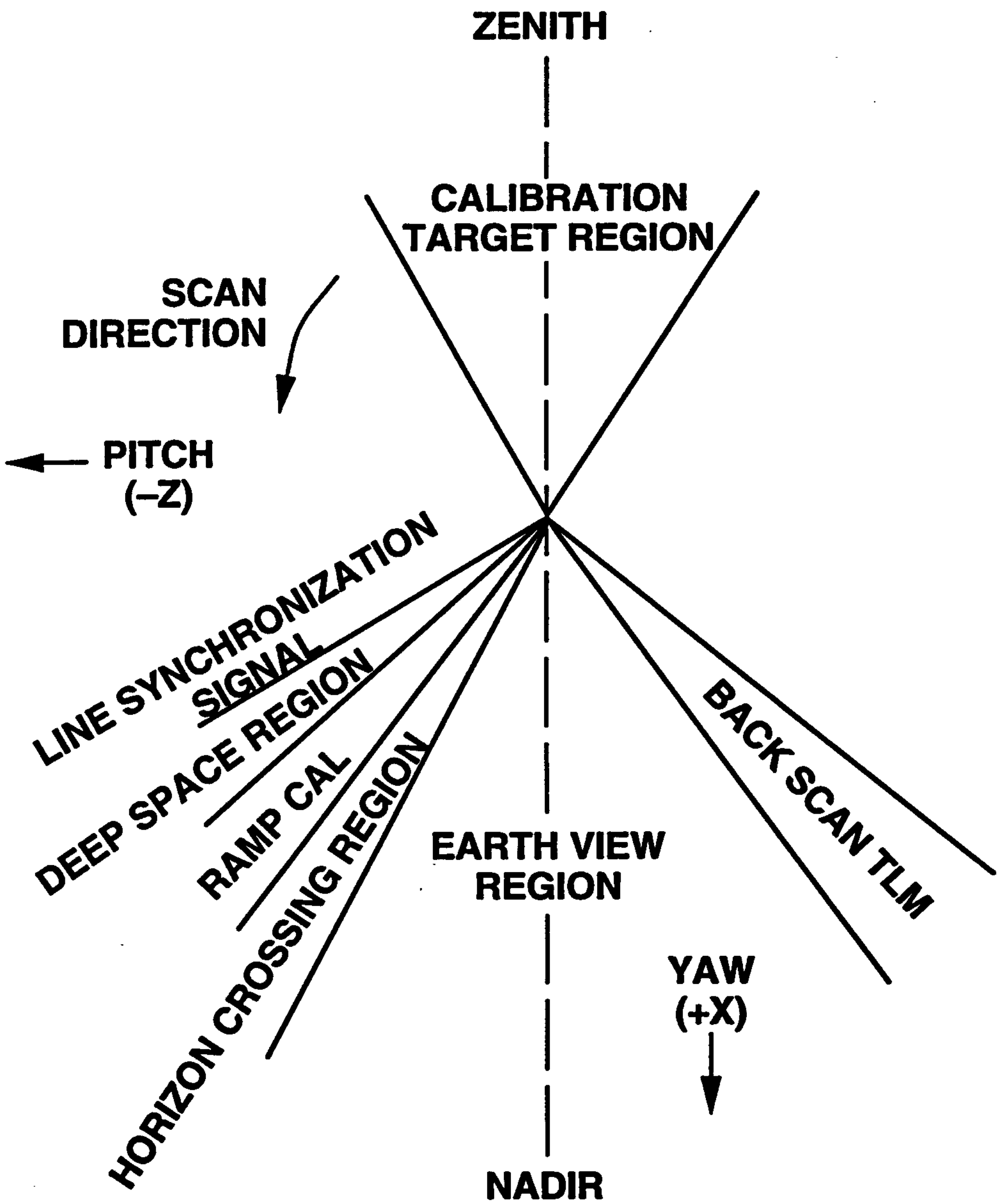


Figure 3. Signal Position As a Function of Scan Angle

5.7.5. Digital "B" (Command Verification) Telemetry

Each command shall be provided with Command Verification Telemetry which confirms that the command has been received. One digital telemetry channel shall be provided for each command pair as indicated in Table 2.

Command Verification Telemetry Outputs shall comply with the following requirements:

1. Signal Levels:
   Logic True: -0.1 volts to +0.4 volts
   Logic False: +5.0±0.7 volts
2. Output Configuration:
   Single-ended, DC coupled
3. Output Impedance:
   15.0 K ohms maximum
   2.0 K ohms minimum
4. Source/Sink Current:
   1 micro ampere maximum
5. Overrange Limits:
   -0.7 volts to +6.0 volts

5.7.6. Analog (Housekeeping) Telemetry

The analog telemetry shall be available at the instrument interface at all times that the instrument is turned on. The operating range of these parameters, listed in Table 3., shall fill the entire scale of the telemetry to ensure maximum resolution.

Analog Telemetry Outputs shall comply with the following requirements:

1. Signal Levels:
   +0.2 to +5 volts referenced to signal ground

2. Output Configuration:
   Single-ended, DC coupled, referenced to signal ground
3. Output Impedance:
   15.0 K ohms maximum
   2.0 K ohms minimum
4. Load Impedance:
   2 Megohms minimum
5. Source/Sink Current:
   1 micro ampere maximum
6. Overrange Limits:
   -0.7 to +6.0 volts

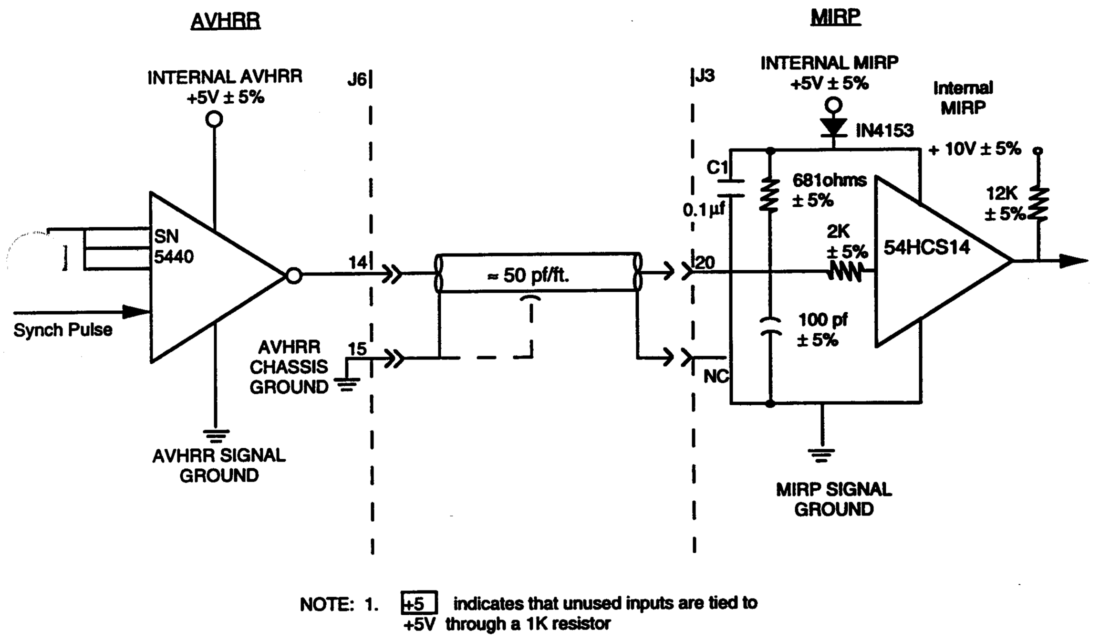


Figure 4. AVHRR/3 - MIRP Line Synchronization Pulse Interface

5.8. MULTIPLEXER AND ANALOG TO DIGITAL ELECTRONICS

The analog to digital (A/D) subsystem shall consist of a multiplexed and an A/D converter(s). The A/D converter(s) shall be capable of sampling, holding, and transferring a digitized value under control of the processor.

5.8.1. Multiplexer

The multiplexer voltage offset or other errors shall degrade the overall A/D conversion accuracy less than $\pm$1/2 Least Significant Bit (LSB).

5.8.2. Analog to Digital Converter

The accuracy of the A/D converter at 15°C Instrument Baseplate temperature shall be $\pm$1/2 LSB maximum allowable error. In addition, the differential nonlinearity (the bit-to-bit variation) shall not exceed $\pm$1/2 bit. Over the temperature range of 10°C to +30°C Instrument Baseplate temperature the maximum error shall not exceed ±1 LSB. The converter shall digitize analog inputs from all six channels.

5.8.3. Channel Crosstalk

The output signal presented to the A/D for each of the six channels shall be independent of past signals in that channel and signals in other channels. Errors in the multiplexer and the A/D converter due to both static and dynamic (AC) crosstalk shall be 1/2 bit or less.

5.9. INTERNAL BLACKBODY TARGET TEMPERATURES

The temperature of the calibration target shall be monitored by means of several resistance thermometers embedded in the honeycomb each of which shall have a temperature resolution of 0.1°C or better with a goal of 0.05°C.

The signal from each of the platinum resistance sensors in the internal blackbody target shall be inserted into the composite analog video signal in each channel one signal per scan line, following the end of the earth scan. The signal from the first temperature sensor shall be inserted in the first scan line; the signal from the second temperature sensor shall be inserted in the second scan line, etc., until all four of the temperature sensors have been interrogated.

The scan line immediately following the scan line which contains the last temperature sensor shall contain "0's" (zeros) in at least the first six significant bit locations.

The duration of each temperature signal shall be approximately 100 microseconds.

5.10. INSTRUMENT INPUT SIGNALS

The presence of any or all or none of the input signals to the instrument applied in any sequence shall not damage the instrument, reduce its life expectancy or cause any malfunction, either when the radiometer is powered or when it is not.

5.10.1. 0.9984 MHZ Spacecraft Timing Signal Input

The spacecraft shall supply to the instrument a 0.9984 MHZ timing signal with the following characteristics:

1. Signal type - Constant frequency symmetrical trapezoidal wave.
2. Frequency - 0.9984 MHZ.
3. Frequency Stability - The drift shall be less than ±3 parts in 10^8 per week, and less than ±2 parts per 10^6 per year. Short term instability shall be less than 5 parts in 10^9 in 1 minute.
4. Waveform Symmetry - The signal symmetry shall be greater than 60%. See GIIS, for additional information.
5. Rise and Fall Times - The clock transition times with the specified load shall be 0.26 milliseconds or less for the 10 to 90% amplitude points, with EMI-

suppression ferrite beads in the Instrument Mounting Platform (IMP) cables.

6. Signal-to-Noise Ratio - The signal to noise ratio of the timing signal shall be at least 20 db peak-to-peak signal to rms noise. The noise peaks shall not exceed one fourth of the clock signal amplitude.

7. Interface - The 0.9984 MHZ clock signal shall be transmitted to the instrument by an interface circuit to be specified by LM within 1 year after award of contract. A candidate circuit consists of a SN55109A balanced line driver through a twisted pair, double shielded cable to a SN55107A balanced line receiver in the instrument, see Figure 5. There shall be 50 ohm 5% composition carbon resistor terminations to ground at the transmitting and receiving ends of this interface circuit. The cable shall be continuous and uninterrupted from the connector on the box containing the driver to the clock connector on the AVHRR/3 instruments. The AVHRR/3 line receiver shall be connected to the clock connector via a twisted pair, single shielded cable. The AVHRR/3 receiver terminations shall be as close to the end of the twisted cable end going to the line receiver as is practical.

No RF beads or filters shall be placed on any of the cable connections of this clock interface unless it can be demonstrated that EMI is indeed reduced and that the clock signal quality is not compromised.

5.10.2. Data Sample Pulses from MIRP

These pulses control the radiometer data channel sampling times. Simultaneous sampling of all channels is required. The minimum time between samples is 25t to 30t. The analog data is digitized and read out simultaneously on ten (10) AVHRR data output lines (parallel read-out) at five (5) predetermined times following each sample pulse.

5.10.2.1. Timing

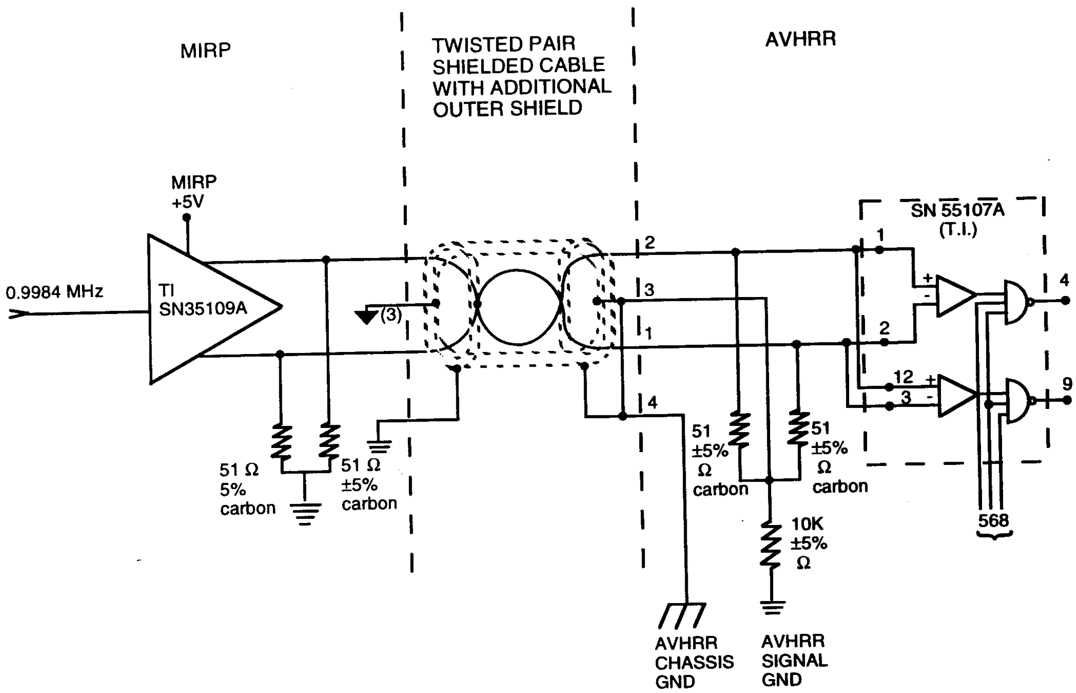
1. Pulse Width: One period of the 0.9984 MHZ clock (t = 1.001602546 microseconds).

2. Sampling Rate: 39,936 sample pulses per second (Time between samples: = 25t).

3. Data Word Rate to MIRP: Five 10-bit AVHRR data words per Sample Pulse = 199,680 words per second.

5.10.2.2. Phasing

Each sample pulse shall be phased so that a negative going edge of the 0.9984 MHZ clock will occur during the high or true state of the sample pulse.



NOTES:
1. The 0.9984 MHz clock supplied to the AVHRR on J5 pin 2 shall have the phase relationship to the Data Sample Pulse that is shown in Figure 2.
2. Shielded wire is #24 AWG.
3. MIRP Signal Ground (+5V).
4. Cable shields covered by insulating jackets.
5. Cable continuous from MIRP to AVHRR.

Figure 5. Clock Driver/Receiver Interface Circuit

5.11. COMMAND SYSTEM CHARACTERISTICS

The spacecraft command and control subsystem (C&CS) shall utilize COS/MOS family logic to transmit commands to the radiometer. A number of these commands may be stored for delayed execution. Command signal interfaces in the radiometer shall comply with the following requirements:

5.11.1. Command Signal Electrical Characteristics

Each command shall be a single unbalanced bi-level signal supplied from a CD4041A COS/MOS logic element in the spacecraft C&CS and transmitted to the radiometer on a separate wire as illustrated in Figure 6. Command signals shall have the following characteristics:

1. Levels: Steady-state signal levels shall be 0.0±0.2 volt (low, or "true", or "on", or "data one") and +10.0±0.7 volts (high, or "false", or "off", or "data zero") referenced to spacecraft ground.

2. Rise and Fall Times: In all cases, rise and fall times refer to transition between 10% and 90% points of nominal squarewave signal amplitude. Rise and fall times of command signals from an open circuited command output on the spacecraft C&CS shall not be less than 2.0 microseconds. Rise and fall times of command signals loaded by a radiometer command input circuit shall not exceed 15.0 microseconds.

3. Pulse Width: The command pulse width shall be 1.0 +1.0/-0.5 seconds. The pulse width shall be measured between the points where the command pulse is greater than 90% of the nominal squarewave amplitude.

5.11.2. Command Signal Receiving Circuits

Each command input on the radiometer shall be fed to a CD4000A Series logic element or its electrical equivalent. There shall be DC isolation of 1.5 kilohms or greater between each command input and ground. The total shunt capacitance from input to ground shall be 5600±10% picofarads.

5.11.3. Command Interface Restraints

The following additional restraints are imposed on the command interface:

1. Diodes. Relay winding diode suppression shall be used.

2. Separate Connectors. All command input lines shall be wired to a connector separate from connectors used for other functions.

5.12. SCAN MIRROR DRIVE

The radiometer scan mirror drive shall meet the following requirements:

1. Rotation of the scanning mirror shall be accomplished by a single motor through a direct drive system. The scan motors for flight models A303, A305 and higher, and a flight spare, shall utilize a closed loop control system. CCR1771 MOD 196

2. The scanning system shall be rotated at the rate of 360 rpm to ensure contiguity of adjacent scans at the sub-satellite point for the 0.59 nmi resolution channels. The scan rate shall be synchronized with the 0.9984 MHZ clock signal.

3. Scanning System Motor - The motor shall have adequate torque to operate properly (within instrument synchronism and drift requirements) at the end of lifetime and over the instrument temperature range. The system shall

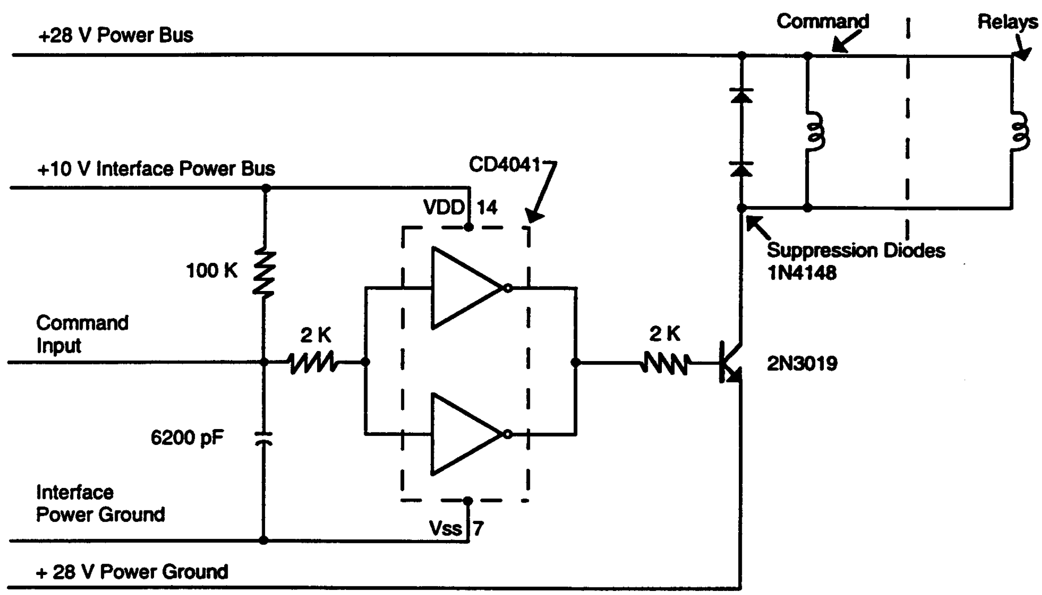


Figure 6. AVHRR/3 Command Receiver (Dual Relay)

have a minimum demonstrated start of life torque margin of 0.85:1 with the motor commanded in LOW or HIGH mode. Torque margin equals the ratio of available motor torque to bearing drag torque, minus one. The motor shall be operated during launch phase.

3.1 Definitions

3.1.1 Bearing Drag Torque

Bearing Drag Torque is measured in the motor at the normal operating speed and ambient temperature (22°C), with the windings disconnected from the circuit.

4. Angular Momentum - The maximum angular momentum of the AVHRR/3 shall be less than 0.268 Newton-m-sec.

5. The motor shall be operated during liftoff.

5.13. SCAN LINEARITY, SCAN SYNC DRIFT AND JITTER

5.13.1. Scan Linearity

Following a one hour warm-up period there shall be less than $\pm$17 microsec (2 of an IFOV) of deviation between the measured scan period of any scan line and a reference sync pulse that occurs every 166,400 cycles of the 0.9984 MHZ clock. 98% of the measured scan periods taken over a minimum 20 minute period shall meet this criterion. The scan period shall be measured as the number of 0.9984 MHZ clock cycles between sync pulses and shall be made for every scan line during the measurement period. The scanner sync pulse occurs once per revolution of the scanner as a reference point passes a sensor.

5.13.2. Scan Synchronization Drift

The average drift of the scanner sync pulse relative to the spacecraft's 0.9884 MHZ clock shall be less than ±3.0 microsec during a 24 hour period. Average drift shall be determined from the slope of a regression line that best fits a minimum of 48 data points where the data points are a periodic measurement of Net Drift. Net Drift is defined as an instantaneous measurement of the time difference between the scanner sync pulse and a reference sync pulse that occurs every 166,400 cycles of the 0.9984 MHZ clock.

5.13.3. Line-Line Jitter

Following a one hour warm-up period there shall be less than 34 microseconds (1 IFOV) peak-to-peak variation of sync. delta for 98% of sync. delta measurements taken every scan line over a 20 minute period. Sync delta is defined as the difference in scan periods between two adjacent scan lines where each scan period is measured as the number of .9984 MHZ clock cycles between sync pulses and shall be made for every scan line during the measurement period.

5.14. TEST POINTS

5.14.1. Description

Test points shall be provided to permit selected analog signals within the radiometer to be monitored and to control certain portions of the instrument for troubleshooting purposes. During final acceptance and calibration tests all test points/connectors shall be stowed as they would be in orbit. Protection against accidental short circuit to ground or to as high a voltage as ±28 vdc shall be provided. The radiometer shall operate within specification after an accidental short or over voltage condition is removed.

5.14.2. Suggested Test Points

The following are suggested test points for the AVHRR/3 instruments:

No.	Function
1	Test - Pick-up loss simulation
2	Test (Ramp Calibration)
3	Channel 4 (10.8 u) Test
4	Channel 3A (1.6 u) Test
5	Channel 1 (0.63 u) Test
6	Channel 2 (0.86 u) Test
7	+6.4 vdc Reference Voltage Test Point
8	Pick-up #1 Test
9	Pick-up #2 Test
10	- 15 vdc Test
11	+15 vdc Test
12	Clock Receiver Test
13	Solenoid #1 Test

14	Solenoid #2 Test
15	+5 vdc Test
16	Signal Ground
17	Synchronization Pulse
18	Channel #5 (12 u) Test
19	Ramp Calibration Inhibit
20	Channel #3B (3.7 u) Test
21-48	Spare (A301 through A303)
21	Spare (A304 and up)
22	Channel 4 Offset (A304 and up)
23	Channel 4 Bias Disable (A304 and up)
24	Channel 5 Offset (A304 and up)
25	Channel 5 Bias Disable (A304 and up)
26-48	Spare (A304 and up)
49,50	Chassis Ground

5.14.2.1. Characteristics

The characteristics of the test point signals shall be as follows:

1. Signal Type - same as signal being monitored.
2. Signal Amplitude - same as signal being monitored.
3. Output Impedance - a maximum of 10K ohms.
4. Output Configuration - single-ended, one pin per test point output.

5.15. POWER SYSTEM

5.15.1. General

The AVHRR/3 subsystem power supply shall provide all power needed to operate the system except as noted. The system shall operate from the spacecraft +28 V power system, which will be supplied to the instrument in the form of a fused +28 V main bus. A +28 vdc telemetry bus will be available from the spacecraft for limited telemetry circuit loads. A +10 vdc bus will be available from the spacecraft for limited interface circuit loads.

Any dc/dc converter within the AVHRR/3 shall be coherent with the spacecraft clock (at the same frequency or any subharmonic frequency of the spacecraft clock). In the event that more than one dc/dc converter is utilized, one shall be designated as the prime converter and synchronized to the spacecraft clock. The others shall be synchronized to the prime converter to eliminate intra- instrument beat frequencies.

5.15.2. Spacecraft Power System Compatibility

The instrument shall function within specifications and shall be compatible with the spacecraft power system. See the GIIS, for additional information.

5.15.3. Instrument Operating Characteristics

The AVHRR/3 shall display the following operating characteristics:

1. Normal Operation/Input Voltage Range The AVHRR/3 shall perform within specification when operated from the main power bus even if the voltage on that bus should vary from +26 V to +30 V.

2. Over Voltage Protection The AVHRR/3 shall withstand a continuous over voltage on the +28 V main power bus of +38 vdc and on the +10 v bus of +15 vdc without damage. Under these conditions, components shall not be stressed beyond their specified maximum ratings (including the effect of environment). The AVHRR/3 shall be operating within specification within three minutes after the over voltage is removed.

3. Turn-on Load Current Turn-on surge current drawn by the AVHRR/3 at switch-on shall not exceed 3 A peak. Steady state conditions shall be attained within 30 ms from the start of the transient. The rate of change of current for the +28 vdc bus during the switch-on shall not exceed 20 ma/microsecond except under the bus fault conditions. Transient current measurements shall be made with an instrument whose bandwidth is at least 1 MHZ.

4. Feedback Ripple or Noise The peak-to-peak amplitude of steady state load current ripple generated by the instrument shall not exceed 2 percent of the maximum average steady state current. The fundamental frequency of the load current ripple shall not exceed 100 kHz. The converter frequency shall not be a submultiple of the 121.5 MHZ±15 KHz SAR band.

5. Input Configuration Two pins in parallel shall be used for both the regulated power input and return. One input and one return line shall be routed to the connector. The regulated power return shall not be connected to the case ground of the AVHRR/3 and all input leads shall be isolated from the case by at least 10 Megohms.

6. Fusing There shall be no fuses internal to the instrument. Fusing will be supplied by the spacecraft power system.

7. +10 vdc Input filter An input filter shall be connected to the +10 V bus. See the GIIS for additional information.

8. Load Current Overshoot Transients Load current overshoot transients, exclusive of motor start-up loads, drawn by the radiometer shall not exceed 150 percent of the maximum steady state current drawn from the +28 volt bus and shall not exceed 30 milliseconds in duration.

9. Motor Start-up Current Motor start-up current loads shall be limited to 1.0 ampere maximum for a period of one second or less. Turn on transients of the cooler decontamination heater shall be limited to 3.3 amperes for a period of 2 milliseconds or less, and the cooler door opening transients shall be limited to 2.1 amperes for a period of 1 second or less. The rate of change of current during these transients shall not exceed 20 milliamperes per microsecond. Transient current measurements shall be made with an instrument whose bandwidth is at least 1 MHZ.

5.16. CONNECTOR REQUIREMENTS

5.16.1. Instrument/Spacecraft Interface Connectors

The contractor shall provide separate connectors for the following inputs and outputs:

a. J1Command
b. J2Digital TM
c. J3Power
d. J4Analog TM
e J5Clock
f. J6Data Processor
g. J7Test
h. J33TCE Heater

5.16.2. General

Connectors shall be keyed, have different numbers of contacts or be of different sex to prevent accidental mismating. On the chassis, male connectors shall be used for power and input signals, and female connectors shall be used for output signals. Where possible, ten percent of the total number of contacts on each connector shall be spares (not connected).

Crimp-on contact terminations shall be used in preference to solder-type whenever possible.

1. Connector Designations The connector designations shall be the same as those used on NOAA-H, I, J. See TIROS-N Unique Interface Specification for the AVHRR, IS20029950, for additional information.

2. Connector Marking Each connector shall be marked with the corresponding identification number shown on the electrical circuit diagrams. The marking shall be readily visible and shall contrast with the surface on which it is displayed.

3. Connector Types Table 5 contains typical Cannon D connector type numbers. The actual types of connectors used will be determined by EMI requirements.

5.16.3. Connector Savers

Connector savers shall be provided and installed on the instrument's flight connectors as soon as the instrument is assembled. The connector savers shall be used to reduce to a minimum the number of mate/demate cycles of the instrument flight connectors. Mates and demates on the flight connectors shall be limited to fifty mates and fifty demates each. Mate/demate logs shall be established and maintained for all flight instrument interface connectors. Connector savers shall be constructed using standard wire and flight type connectors.

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TABLE 5

Connector Type 37 Pin Male GSFC 311P405-4P-C12 (Mod 123)

J1 Command Connector

Pin No.	Function	Pin No.	Function
1	Elec/Telemetry ON	19	Spare
2	Elec/Telemetry OFF	20	Patch Control Off
3	Motor/Telemetry ON	21	Patch Control ON
4	Motor/Telemetry OFF	22	Earth Shield Disable
5	Telemetry Not Locked On	23	Earth Shield Deploy
6	Telemetry Locked ON	24	Cooler Heat OFF
7	Channel 1 (0.63 u) Enable	25	Cooler heat ON
8	Channel 1 (0.63 u) Disable	26	Voltage Calibrate OFF
9	Channel 2 (0.86 u) Enable	27	Voltage Calibrate ON
10	Channel 2 (0.86 u) Disable	28	Channel 5 (12 u) Enable
11	Channel 4 (10.8 u) Enable	29	Channel 5 (12 u) Disable
12	Channel 4 (10.8 u) Disable	30	Channel 3A (1.6 u) Enable
13	Channel 3B (3.7 u) Enable	31	Channel 3A (1.6 u) Disable
14	Channel 3B (3.7 u) Disable	32	Channel 3A Output Select
15	Motor Low Power	33	Channel 3B Output Select
16	Motor High Power	34	+10V I/F GND A AVH RTN / Spare
		35	+10V I/F GND B AVH RTN / Spare
17	Spare	36	Chassis Ground
18	Spare	37	Chassis Ground

TABLE 5 (Continued)

Connector Type - 25 Pin Female GSFC 311P405-3S-C-12 (Mod 123)

J2 Digital TM

Pin No.	Function	Pin No.	Function
1	Earth Shield Status	10	Channel 1 (0.63 u) Status
2	Patch Control Status	11	Channel 2 (0.86 u) Status
3	Spare	12	Channel 4 (10.8 u) Status
4	Motor Mode Status	13	Channel 3B (3.7 u) Status
5	Voltage Calibrate Status	14	Channel 5 (12 u) Status
6	Cooler Heat Status	15	Channel 3A (1.6 u) Status
7	Electronics/Telemetry Status	16	Ch 3A/3B Output Select
8	Motor/Telemetry Status	17 - 21	Spare
9	Telemetry Lock Status	22	+10V I/F GND C AVH RTN / Spare
		23	+10V I/F GND B AVH RTN / Spare
		24	Chassis Ground
		25	Chassis Ground

TABLE 5 (Continued)

Connector Type - 25 Pin Male GSFC 311P405-3P-C-12

J3 Power

Pin No.	Function	Pin No.	Function
1	+28V Bus	10	+10V Bus
2	+28V Bus	11	Spare
3	+28V Bus (Motor)	12	Spare
4	+28V Bus (Motor)	13	Interface Power Ground
5	Power Ground	14	Interface Power Ground
6	Power Ground	15	Signal Ground
7	AC 28V Return	16	Signal Ground
8	AC 28V Return	17	Chassis Ground
9	+10V Bus	18	Chassis Ground
		19 - 25	Spare

TABLE 5 (Continued)

Connector Type - 37 Pin Female GSFC 311P405-4S-C-12 (Mod 123)

J4 Analog TM

Pin No.	Function	Pin No.	Function
1	Radiator Temp. TM	13	Base Plate Temp. TM
2	Patch Power TM	14	A/D Conv. Temp. TM
3	Patch Temp TM Low Range	15	Motor Hsg. Temp. TM
4	Patch Temp TM Ext Range	16	Cooler Hsg. Temp. TM
5	Black Body #1 TM	17	Det Bias Volt CH 4 (10.8 u) TM
6	Black Body #2 TM	18	Det Bias Volt CH 5 (12 u) TM
7	Black Body #3 TM	19	BB Temp. IR CH 4 (10.8 u) TM
8	Black Body #4 TM	20	BB Temp. IR CH 3B (3.7 u) TM
9	Motor Current TM	21	Offset Voltage TM
10	Elect. Current TM	22	BB Temp IR CH 5 (12 u) TM
11	Earth Shield Position TM	23 - 33	Spare
12	Electronics Temp. TM	34	Signal GND A AVH GND / Spare
		35	Signal GND B AVH GND / Spare
		36	Chassis Ground
		37	Chassis Ground

Connector Type - 9 Pin Male GSFC 311P405-1P-C-12

J5 Clock

Pin No.	Function	Pin No.	Function
1	Clock - Ref	6	Spare
2	Clock	7	Spare
3	Clock Shield	8	Spare
4	Chassis Ground	9	Spare
5	Chassis Ground		

TABLE 5 (Continued)

Connector Type - 15 Pin Male GSFC 311P405-2P-C-12

J6 Data Processor

Pin No.	Function	Pin No.	Function
1	2^9 MIRP Data	9	2^1 MIRP Data
2	2^8 MIRP Data	10	2^0 MIRP Data
3	2^7 MIRP Data	11	Chassis Ground
4	2^6 MIRP Data	12	Sample Pulse From MIRP
5	2^5 MIRP Data	13	Chassis Ground
6	2^4 MIRP Data	14	Sync Pulse to MIRP
7	2^3 MIRP Data	15	Chassis Ground
8	2^2 MIRP Data		

TABLE 5 (Continued)

Connector Type - 50 Pin Female GSFC 311P405-5S-C-12

J7 Test

Pin No.	Function	Pin No.	Function
1	Test-Pick-up loss sim.	12	Clock Rcvr Test
2	Ramp Cal. 3 level	13	Solenoid +28
3	Ch. 4 (10.8 u) Test	14	Solenoid +28
4	Ch. 3A (1.6 u) Test	15	+5V Test
5	Ch. 1 (0.63 u) Test	16	Signal Ground
6	Ch. 2 (0.86 u) Test	17	Sync Pulse
7	Ref. V Test Point	18	Channel 5 (12 u) Test
8	Pick-up #1 Test	19	Ramp Cal Inhibit
9	Pick-up #2 Test	20	Channel 3B (3.7 u) Test
10	-15V Test	21 - 48	Spare (A301 through A303)
11	+15V Test	21	Spare (A304 and up)
12	Clock Rcvr Test.	22	Channel 4 Offset (A304 and up)
13	Solenoid +28	23	Channel 4 Bias Disable (A304 and up)
14	Solenoid +28	24	Channel 5 Offset (A304 and up)
15	+5V Test	25	Channel 5 Bias Disable (A304 and up)
16	Signal Ground	26 - 48	Spare (A304 and up)
		49 - 50	Chassis Ground

Connector Type - 9 Pin Female 311P405-1S-C-12

J33 Pulse Load Heater

Pin No.	Function	Pin No.	Function
1	Pulse Load Heater	6	Chassis Ground
2	Pulse Load Heater Return	7	Chassis Ground
3	Temp. Control Sensor	8	Spare
4	Temp. Control Sensor	9	Spare
5	Spare		

5.17. MAGNETIC

Since in-orbit experience has shown that the present proven design demonstrates acceptability regarding magnetic requirements, the elements of section 5.17 are not required for the AVHRR/3 unless a change in design places any doubt on this acceptability.

5.17.1. Instrument Generated Magnetic Fields

The AVHRR/3 shall be designed to minimize the permanent, induced, and transient magnetic field effects. The magnetic field of the instrument shall not exceed 100 gamma at a distance of one meter from the instrument.

5.17.2. Instrument Magnetic Susceptibility

Each instrument shall be designed so as to minimize its susceptibility to magnetic fields and shall operate within specification while exposed to 2 gauss fields.

5.17.3. Magnetic Compensation

In the event that permanent magnets or magnetic materials present in the AVHRR/3 interacts with the spacecraft stabilization and control subsystem to the extent that the performance of that subsystem is adversely affected, suitable design compensation shall be required of the instrument.

5.17.4. Instrument Degaussing

The instrument shall operate according to specification following up to two degaussing exposures. Each degaussing exposure shall have a maximum field of 30 gauss and maximum frequency of 60 Hz.

5.17.5. Magnetic Field Environment

The spacecraft will generate magnetic fields during normal orbital operations. The maximum unloading coil fields will be generated during angular momentum unloading which occurs in a $+24^\circ$ zone around both poles and in a $+8^\circ$ zone centered at $\pm 35^\circ$ latitude.

The maximum magnetic flux the AVHRR/3 instrument will experience on the spacecraft will be 2.0 gauss. This level will be considerably reduced in orbit through the use of magnetic moment compensation.

The spacecraft magnetic moment compensation system contains three chargeable permanent magnets, located parallel to the spacecraft control axes. Each magnet may have a dipole between -14 ATM^2 and +14 ATM^2.

Two of the chargeable permanent magnets are located on panel 1, near the -Z end.

The spacecraft roll/yaw torquing coil is perpendicular to the spacecraft pitch (Z) axis and is attached to the -Z end of the ESM. It is 34 in x 23.3 in and has a dipole of 62.8 ATM^2.

The spacecraft pitch torquing coil is perpendicular to the spacecraft roll (Y) axis and is attached to panel #3 of the ESM. It is 53 in x 17.5 in and has a dipole of 29.9 ATM^2.

The AVHRR/3 shall be built to operate within specification while exposed to these magnetic fields.

5.18. CONDUCTED SUSCEPTIBILITY

The method detailed in the 31 July 1967 (original) revision of MIL-STD-462 shall be referenced in this paragraph.

The radiometer shall perform within specifications in the presence of sinusoidal noise coupled into the power lines between the frequency ranges of 30 Hz to 150 kHz.

The method specified in MIL-STD-462 CS01 shall be used to inject noise between 30 Hz and 150 kHz.

Bus	Injected Voltage
+28 v Bus/TCE Bus	300 mV p-p
+10 v Interface Bus	100 mV p-p

The instrument shall operate without degraded performance when subjected to a series of transient pulses, 10 microseconds in width and repetition rate of 10 Hz applied to the power lines for ten minutes duration. Test method CS06 as described in MIL-STD-462 is applicable.

Bus	Spike Level
+28 v Main Bus	+10 v and - 12 v
+28 v TCE Bus	+8 v and - 13 v
+10 v Interface Bus	+1 v and - 1 v

5.19. RADIATED SUSCEPTIBILITY

The instrument shall operate within specification while subjected to a radiated electric field of one volt per meter for frequencies between 150 kHz and 500 MHZ except that in the band of 136 MHZ to 139 MHZ and 1605 MHZ to 1710 MHZ the field strength shall be 10 volts/meter. The radiated carrier in the band between 136 and 139 MHZ shall be 50% amplitude modulated at a frequency of 8.32 kHz. Modulation at S-band is not required. Testing shall be conducted in accordance with MIL-STD-462, RS03.

5.20. RADIATED ELECTROMAGNETIC INTERFERENCE (EMI)

5.20.1. EMI Construction Techniques

The Contractor shall use good EMI construction practices to minimize the radiation of and susceptibility to EMI of the AVHRR/3 instruments. Contractor efforts in this regard shall include, but not be limited to:

1. Route all instrument cabling inside the instrument housings.
2. Design bolt-together seams for minimum EMI leaks.
3. Run all connections to the outside world through appropriate filters.
4. Design into electronic circuits EMI reducing techniques, which shall include, but not be limited to, beads, shielding and bypass capacitors.
5. Conduct EMI screen room tests of each instrument at the Contractor's facility to demonstrate immunity to EMI from the spacecraft transmitters at flux levels expected at each instrument and to demonstrate compliance with radiated emissions requirements.

5.20.2. Radiated EMI

The AVHRR/3 instruments shall meet the radiated EMI requirements listed in paragraph 3.6.1.4 Radiated Emissions of the GIIS for additional information.

5.21. CONDUCTED EMISSION

An oscilloscope with a current probe, DC to 30 MHZ minimum bandwidth, may be used in lieu of an EMI meter as specified in MIL-STD-462 to determine if the allowable limits are exceeded. Photographs of traces shall have sufficient resolution to clearly indicate ripple magnitude, frequency and risetime to demonstrate compliance with this specification.

The measurements shall be performed on all power lines and returns interfacing with the spacecraft.

Test Method	Frequency
MIL-STD-462	Ranges
CE01	20 Hz - 20 kHz
CE02	20 kHz - 150 kHz

See TIROS-N Unique Interface Specification for the Advanced Very High Resolution Radiometer, IS-20029950 for more information.

5.22. GROUNDING AND SHIELDING

The following paragraphs define the grounding and shielding requirements for the AVHRR/3 circuits and the electrical interface between the AVHRR/3 and the TIROS-N spacecraft.

5.22.1. Case Ground

The case ground is any chassis and/or box which houses electronic circuits in the AVHRR/3.

1. The mounting surfaces of the case shall be finished with an electrically conductive finish. All case junctions shall be electrically conductive to optimize shielding.

2. The case shall be grounded to the spacecraft structure directly or via a ground bonding strap.

3. The case ground shall be DC isolated from all input and output circuitry by at least 10 megohms when the single point ground within the instrument is lifted.

4. The case ground shall be connected within the radiometer via the shortest possible connecting lead to at least two contacts on each connector interfacing with the spacecraft.

5.22.2. Power Grounds

1. The AVHRR/3 shall have four separate power grounds:

    a. The +28 volt DC power return.

    b. The +28 volt motor power return.

    c. The interface power ground return for the +10 volt power.

    d. The TCE heater power return.

2. Each power ground shall be DC isolated from all other grounds within the AVHRR/3 by at least 5 megohms prior to external connection.

3. Each power ground shall be connected by a separate wire in the spacecraft harness to the spacecraft central ground point.

5.22.3. Signal Ground

1. Signal ground shall be DC isolated from the 28 volt power input circuit by means of a DC to DC converter.

2. DC isolation between signal ground and the 28 volt power ground shall be at least 10 megohms when the single point ground inside the instrument is lifted.

3. All single-ended input and output signal returns shall be connected to signal ground.

5.22.4. Shielding

1. The shield on any wire within the AVHRR/3 may be connected to signal ground or case ground but not both. The ground connection shall be made at one end of the wire only unless EMI reduction requires otherwise.

2. Shields on spacecraft harness wires interfacing with the AVHRR/3 which carry unbalanced outputs from the radiometer shall be connected to the case ground contact in the mating connector at the radiometer.

3. Shields on spacecraft harness wires interfacing with the AVHRR/3 which carry unbalanced inputs to the radiometer shall be connected to a pin in the mating connector at the AVHRR/3. This pin is not connected to anything within the radiometer.

4. Double-shielded spacecraft harness wires interfacing with the AVHRR/3 which carry balanced signals shall have the outer shield connected to case ground through a pin in the mating connector at the radiometer. The inner shield shall be connected to a pin in the mating connector at the radiometer which is returned to signal ground.

6. MECHANICAL REQUIREMENTS

6.1. GENERAL MECHANICAL DESIGN REQUIREMENTS

6.1.1. Mechanical Safety Factors

The load bearing mechanical components of the instrument shall be designed for strength safety factor of 1.4 on ultimate considering the applicable flight test requirements of this specification. All Flight hardware must be exposed to a sine burst and random test. CCR 1618A MOD 177

6.1.2. Natural Resonances

The minimum natural frequency of all components or combinations of components shall be greater than 100 Hz as a goal to avoid coupling with the spacecraft structure resonance.

6.1.3. Lubrication

The lubricant used for bearings, gears and other mechanical drives must be consistent with the required life of the instrument in orbit. Oil and grease quantities added to bearings shall be determined by weight to the nearest 0.1 mg.

6.1.4. Screw Fastening

Approved adhesives shall be used to prevent loosening during environmental testing and launch.

6.1.5. Cements and Epoxies

The use of cements and epoxies should be minimized. Only cement and epoxies on the approved materials list may be employed. Whenever feasible mechanical backup shall be provided where cement or epoxies are used for the fastening of optical or mechanical components.

6.1.6. Identification Name Plate and Marking

All AVHRR/3 hardware shall be marked with the name of the unit, part number, serial number, and connector designations per MIL-STD-130D.

1. Name Plates The flight instruments shall be permanently marked with a label of the following form:

   Instrument: AVHRR/3
   Contractor: ITT
   S/N: (A301 through A308 as appropriate)

2. Marking of Support Hardware, Cables, and Shipping Containers All support hardware must be marked or tagged to insure against loss and to facilitate its usage. Test cables should be tagged, numbered, and identified with the instrument hardware. The same applies to test equipment, and miscellaneous test, and support equipment.

6.1.7. Instrument Shipping Containers

The Government-furnished shipping containers are designed to protect, ship and store the instruments. The container are capable of being pressurized with dry nitrogen and include shock protection and shock and temperature recorders.

The contractor shall purge and pressurize the containers with dry nitrogen and service the recorders as required whenever an instrument is placed in a container.

The Contractor shall provide one shipping container to be used for shipping the AVHRR to its European MetOp destination. The container shall be capable of being pressurized with dry nitrogen and shall have a shock and temperature recorder. The container shall be able to withstand air transportation and have a shock mount that will limit the load on the AVHRR instrument to less than 20 g's when subjected to an 8" drop above a concrete floor. CCR 1821 MOD 205

6.1.7.1. Marking Shipping Container

Each shipping container shall be externally marked with the following information:

1. Manufacturer's part number.
2. Flight unit's model and serial number.
3. Purchase order number.

In addition, any special handling or unpacking directions which are required shall be prominently displayed on the outside of the shipping container.

6.1.8. Instrument Handling Fixture

The contractor shall provide or modify existing handling fixture to accommodate the AVHRR/3. Three fixtures, one for use at the contractors facility, one for use at the TIROS spacecraft contractors facility, and one for use at the METOP spacecraft contractors facility. The handling fixtures designated for use at both spacecraft contractors□ facilities shall be designed to lift and position the AVHRR/3 for mounting on the spacecraft with a crane.

6.1.9. Bearings

Bearing enclosures and output shafts shall reflect an enhanced configuration of the AVHRR/2 design to meet the three-year operational lifetime.

6.1.10. Center of Gravity

The center of gravity shall be measured on each instrument to within 0.2 in. as part of the qualification and acceptance testing.

6.1.11. Materials

Nonmagnetic materials shall be used whenever possible. Cadmium and zinc metal shall not be used in the construction of the instrument.

All printed circuit boards shall be conformally coated with an approved material.

1. Moisture and Fungus Resistance Materials that are not nutrient for fungi shall be used whenever possible. The use of materials that are nutrient to fungi is not prohibited in hermetically sealed assemblies. If it is necessary to use nutrient materials in other than the above qualified applications, these nutrient materials shall be treated by a method that renders the resulting exposed surface fungus resistant.

2. Corrosion of Metal Parts Metal parts shall be made from materials inherently corrosion resistant or shall be processed to resist corrosion. Bare aluminum shall be used only where infrared properties permit no substitute.

3. Outgassing of Material Materials shall not outgas, vaporize, or otherwise degenerate in a space environment in a manner and to a degree as to interfere with the operation of the instruments. Each component shall be free from residual contaminants such as corrosion, inhibiting oils, greases, dyes, shim stock and similar debris.

4. Materials Selection Selection criteria for outgassing shall be based on Goddard Report, "A Compilation of Low Outgassing Polymeric Materials Normally Recommended for GSFC Cognizant Spacecraft," X-764-71-314. The maximum weight loss shall be 1.0 percent or less and the maximum volatile condensable materials shall be 0.1 percent or less.

5. Materials and Process Listing The contractor shall prepare and furnish a materials and process list for the materials used in the AVHRR/3 prior to the preliminary design review meeting. It will categorize all materials listed as metals, plastics, coatings, miscellaneous, etc., and adequately identify the items by government specification, process, cure cycle type, chemical composition and/or manufacturer. The listing will also specify the application(s) of each material in the subsystem.

The volume and surface area of each material will be indicated using the code outlined below:

Volume		Surface Area	
Code	cc	Code	cc
A	0 to 1	1	0 to 1
B	1 to 50	2	1 to 100
C	50 to 100	3	100 plus
D	100 plus		

6.1.12. Finish

The external finishes applied to the scanner unit shall satisfy the mechanical, optical and thermal requirements of the spacecraft and the AVHRR/3.

6.1.13. Maintainability

The contractor shall, to the maximum extent possible, use standard parts, tools and test equipment; consider interchange ability in design, including replacement of printed circuit boards; reduce to a minimum need for adjustments, alignments, and calibrations; employ means to ease identification of fault detection and isolation techniques, and design into instruments fail safe design features.

6.1.14. Protective Covers

Protective covers made of approved materials shall be provided to cover the scan mirror optical port and cooler radiator area. These covers shall provide protection while in the shipping container and during the time the instrument is mounted on the spacecraft and shall minimize dust or dirt from entering these areas. The optical port cover shall not prevent the operation of the scan system. The covers shall be RF transparent. Design of the protective covers for the scan mirror optical port and cooler radiator covers shall incorporate the following criteria:

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- Captive hardware shall be utilized for mounting the covers to the instrument.
- Protective covers may be specific to an instrument.
- Slotted holes shall be eliminated as required to prevent interference between the dust cover and the instrument.

- Blankets shall be provided to aid in light blocking during specific instrument tests. Blankets shall incorporate a removable blanket panel on the Nadir side. Protective covers shall include Velcro for light darkening blanket attachment. The protective covers shall be designed for use with and without all blankets.
- Contact gaskets or Kapton Tape shall be installed on the protective covers so that marring of the painted surfaces will be minimized
- Hardware locations shall be designed so that installation does not require positioning adjustments.

CCR 1786B MOD 242

Covers for all electrical connectors shall also be provided. Flyable covers shall be provided for the test connectors.

6.1.15. Decomposition Products

Design provisions shall be provided to avoid any adverse effects from orbit and adjust subsystem combustion products: H_2, N_2, NH_3, H_2O.

6.1.16. Venting

Venting shall be sufficient to allow the instrument to withstand the launch pressure profile, which for a TITAN II, will be approximately twice as fast as for the ATLAS-E.

6.1.17. Major Components

The AVHRR/3 shall consist of a main frame (or base), a scan assembly, an optical assembly, an electronics assembly, a target assembly and a cooler. See Figure 7.

6.1.18. Mounting Surface

The AVHRR/3 mounting flange surfaces shall be coplanar within 0.005 inches and the total contact area with the spacecraft mounting pads shall be 5.55 square inches consisting of six pads. Six mounting washers per LM Drawing No. 2285701, Rev. C, shall be supplied for each instrument by the contractor.

6.1.18.1. Mounting Hole Pattern

The mounting hole pattern shall be identical to the AVHRR/2 instrument delivered under contract NAS5-26771. Mounting pads of the instruments shall have a 32 rms finish. Any changes in the mounting hole location shall require written approval from the GSFC T.O.

6.1.18.2. Mounting Hole Drill Jig

The existing mounting hole drill jig used on the AVHRR/2 program and currently accounted for under NAS5-29114, will be Government-furnished to the contractor for use on this contract.

6.1.19. Line Synchronization Pulse Pickups

There shall be two line synchronization pulse pickups. The line synchronization pulse pickups shall be built to permit sufficient mechanical adjustment of the sync. pulse relative to other scan mirror events and to allow adjustment of pickup #1 with respect to pickup #2 to be within 10 microseconds of each other.

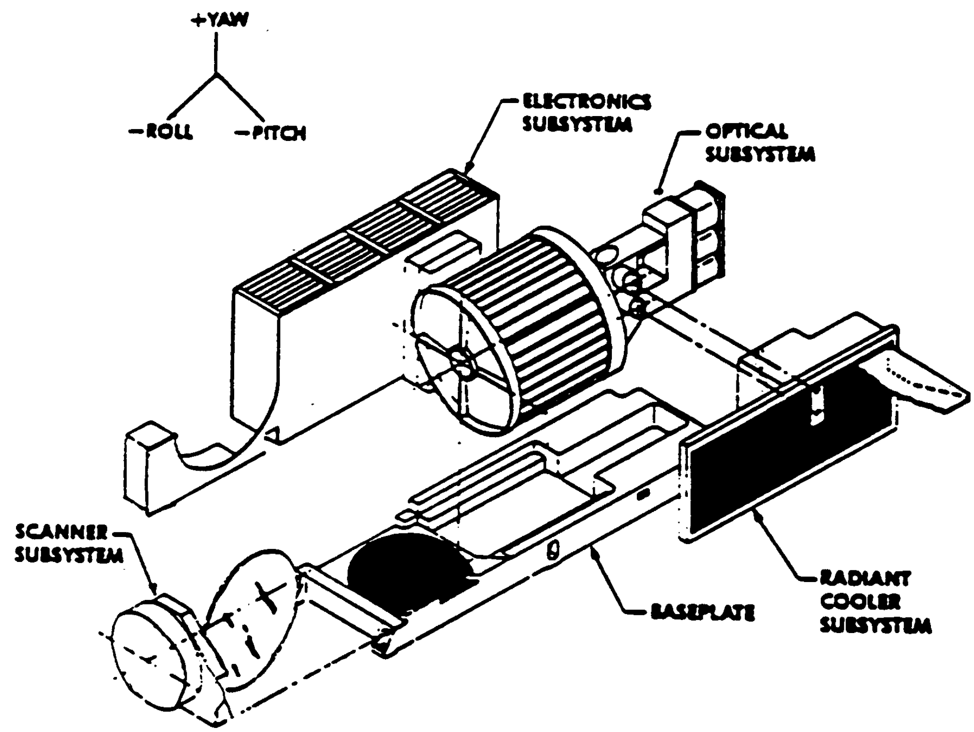

Figure 7. AVHRR/3 Major Components

6.1.20. Optical Assembly

The optical assembly shall consist of the telescope relay optics and visible detector subassembly.

6.1.21. Electronics Assembly

The electronics assembly shall contain all of the system electronics and shall be completely contained within the main instrument package. All electronics shall be built and constructed to provide electromagnetic shielding of all sensitive circuitry from the transient fields created by the dc/dc converters and scan mirror motor circuitry.

6.1.22. Target Assembly

The target assembly shall consist of a honeycomb blackbody mounted to the main frame in a position to be viewed during instrument back scan. This target operating at baseplate temperature, approximately 288°K, is used along with space for in-orbit calibration.

The configuration of the warm calibration target (approx. 288°K) shall be such as to achieve a spectral emittance of 0.99 or better in the spectral range of this instrument. The design of the target shall be such as to minimize its view of the Earth.

6.2 METOP SPECIFIC REQUIREMENTS

CCR 1618A MOD 177

6.2.1 Exceptions to METOP ICD

6.2.1.1 Random Vibration Environment

The qualification and acceptance levels for the random vibration environment shall be 3db below those in Table 4.1.2.4 of the METOP ICD, MO-IC-MMT-0001, June 11th, 1998, Rev. 0.

6.2.1.2 Instrument Shock Environment

The shock environment shall be as shown in Section 4.1.1.3 of the METOP ICD, MO-IC-MMT-HI-0001, June 11th, 1998, Rev. 0. However, this environment will be considered at the interface of the deployable, boom, antenna, etc. that causes the shock load, not at the instrument interface as is implied in the ICD.

6.2.1.3 Vibration Test: High Level Sine Sweep

The qualification levels for the METOP High Level Sine Sweep are as shown below.

6-20 Hz ±9.3 mm

20-60 Hz ±15 g

60-70 Hz ±6 g

70-100 Hz ±3.3 g

Sweep Rate 2 Oct/Min

These levels are to be met in all three axes.

Acceptance levels are shown below.

6-20 Hz ±7.5mm

20-60 Hz ±12 g

60-70 Hz ±4.8 g

70-100 Hz ±3.3 g (TBC by ITT, METOP. This value will not be higher than 3.3 g).

Sweep Rate 4 Oct/Min

These levels are to be met in all three axes.

6.2.2 Factors of Safety

Stress analyses of the instrument shall show a positive margin of safety using a factor of safety on ultimate of 1.4 on qualification levels. If desired, new hardware may be qualified by analysis using a factor of safety on ultimate of 2.0 on qualification levels. Hardware qualified in this manner shall be tested to acceptance levels.

6.2.3 Instrument Testing

If qualified by test, the instrument shall be qualification tested for all environments.

7. OPTICS

7.1. GENERAL REQUIREMENTS

The optics of the AVHRR/3 shall generally consist of such things as a scanning mirror, telescope, beam splitters and optical filters.

7.1.1. Channel 1, 2 and 3A Polarization Requirements

The optical design shall ensure that the effects of polarized radiation on the output of the radiometer, Channels 1, 2 and 3A when the scan mirror is in all scene viewing positions, shall be less than 6%. 4% polarization shall be a design goal.

The percentage effect of polarized radiation on the output of the radiometer shall mean the difference between the maximum and minimum output obtained when a 100% plane polarized source of radiation is rotated through 180°, divided by the sum of the maximum and minimum outputs, expressed in percent.

7.1.2. Spectral Response

The total spectral response shall be specified for each channel and shall include all optics and the detector. This response shall be measured by the contractor.

7.1.2.1. Channel 1

The total response characteristics of channel 1 shall be as follows:

1. The band centroid, as measured between the 50% points, shall be located at 0.63 ±0.01 micrometers.
2. 50% of maximum response points:

   0.58 ±0.02 micrometers with goal of ±0.01 micrometers

   0.68 ±0.02 micrometers with goal of ±0.01 micrometers
3. A separation between the 50% points of 0.10 micrometers shall not be exceeded.
4. 5% response points - Shall be 0.04 micrometers or less from the 50% points.
5. 80% response points - Shall be 0.02 micrometers or less from the 50% points.
6. The response between the 80% response points on opposite sides of the bandpass shall always exceed 80%.
7. The total out-of-band response shall be less than 2% of the total integrated response within the bandpass region when viewing a solar source which stimulates the solar spectral energy distribution.

7.1.2.2. Channel 2

The total response characteristics of channel 2 shall be as follows:

1. The band centroid, as measured between the 50% points, shall be located at 0.862 ∀0.030 micrometers.

2. 50% of maximum response points - Shall be 0.725 ∀0.025 micrometers, and 1.00 ∀0.05 micrometers

3. 5% response points - Shall be 0.04 micrometers or less from the 50% of peak response points on the short wave lengths equal to or greater than 0.685 micrometers. The long wavelength 5% point shall occur within 0.06 micrometers or less from the 50% of peak response point.

4. 80% response points - Shall be 0.02 micrometers or less from the 50% of peak response point on the short wavelength side and 0.20 micrometers or less from the 50% peak response point on the long wavelength side.

5. The response between the 80% response points on opposite sides of the band pass shall always exceed 80%.

6. The band pass region shall extend from 0.08 micrometers below the wavelength of 50% of peak response or to 0.65 micrometers whichever is greater on the low wavelength side and from .08 micrometers above the wavelength of 50% of peak response on the high wavelength side.

7. The total out of band response shall be less than 2% of the total integrated response within the band pass region when viewing a solar source which simulates the solar spectral energy distribution.

7.1.2.3. Channel 3A

The total response characteristic of channel 3A shall be as follows:

1. The band centroid, as measured between the 50% points, shall be located at 1.61±0.01 micrometers.

2. 50% of maximum response points:

   1.58±0.01 micrometers
   1.64±0.01 micrometers

3. A separation between the 50% points of 0.06 micrometer shall not be exceeded.

4. 5% response points - Shall be 0.02 micrometer or less from the 50% points.

5. 80% response points - Shall be 0.01 micrometer or less from the 50% points.

6. The response between the 80% response points on opposite sides of the center frequency shall always exceed 80%.

7. The total out-of-band response shall be less than 2% of the total integrated response within the bandpass region when viewing a solar source which simulates the solar spectral energy distribution.

7.1.2.4. Channel 3B

The total response characteristic of channel 3B shall be as follows:

1. 50% of maximum response points:

   3.55 ± 0.06 micrometers
   3.93 ± 0.06 micrometers

2. The difference in wavelength between the 5% and 80% response points on the same side of the bandpass shall be less than or equal to 0.03 times the wavelength at the 50% response points. The response between the 80% response points on opposite sides of the bandpass shall always exceed 80%.

3. The response shall be equal to or less than 1% of peak for wavelengths less than 3.40 and greater than 4.12 micrometers.

4. The bandpass region shall extend from 3.40 to 4.12 micrometers.

5. The total out of band response shall be less than 2% of the total integrated response within the bandpass region when viewing a 300 K blackbody source.

7.1.2.5. Channel 4

The total response characteristics of channel 4 shall be as follows:

1. 50% of maximum response points:

   10.3 ± 0.09 micrometers

   $11.3 {}^{+0.09}_{-0.13}$ micrometers

2. The difference in wavelength between the 5% and 80% response points on the short wave side of the bandpass shall be less than or equal to 0.04 times the wavelength of the 50% response point. The difference in wavelength between 5% and 80% response points on the long wave side of the band pass shall be less than or equal to 0.05 times the wavelength at the 50% point. The response between the 80% response points on opposite sides of the band pass shall always exceed 80%.

3. The response shall be equal to or less than 1% of peak for wavelengths less than 9.8 and greater than 11.8 micrometers.

4. The bandpass regions shall extend from 9.6 to 12.0 micrometers.

5. The total out-of-band response shall be less than 2% of the total integrated response within the bandpass region when viewing a 300 K blackbody source.

7.1.2.6. Channel 5

The total response characteristics of channel 5 shall be as follows:

1. 50% of maximum response points:

   11.5 ± 0.09 micrometers

   $12.5 {}^{+0.09}_{-0.13}$ micrometers

2. The difference in wavelength between the 5% and 80% response points on the same side of the bandpass shall be less than or equal to 0.04 times the wavelength at the 50% response points. The response between the 80% response points on opposite sides of the bandpass shall always exceed 80%.

2. The response shall be equal to or less than 1% of peak for wavelengths less than 10.9 and greater than 13.1 micrometers.

4. The bandpass region shall extend from 10.7 to 13.4 micrometers.

5. The total out-of-band response shall be less than 2% of the total integrated response within the bandpass region when viewing a 300 K blackbody source.

7.1.3. Detectors

AVHRR/3 detectors shall be used which will satisfy the performance, lifetime and reliability requirements of this specification.

7.1.4. Field of View (FOV) Requirements

7.1.4.1. FOV Width

The field of view shall be square 1.3 ± 0.2 (with a goal of ± 0.1) milliradians on a side. The measurements of this field of view shall be accurate within 0.05 milliradians. This will nominally provide a ground resolution at the sub-satellite point of 0.59 nautical miles. The sides of the square field of view shall be parallel and perpendicular with the scan direction.

The elemental field of view shall be measured by sweeping a slit source of energy (slit perpendicular to the direction of sweep) across the field of view. The elemental field of view shall be defined as the solid angle where the detector voltage response to the slit energy source is 50% of the maximum obtained when the slit source is located on the axis defined by the telescope assembly. The voltage response to this same energy source shall be 1% or less at angular distances equal to or greater than two elemental fields of view from the center of the optical axis. Measurements of the six fields of view shall be made with the scanning system locked in the nadir position.

7.1.4.2. Scanned Field of View

The scanned field of view is the solid angle resulting from rotation of the elemental field of view by the scanning mechanism. The scan axis is defined as the axis about which the scanning mechanism rotates. The optical axis is defined as the axis normal to the plane defined by the back of the primary mirror. The angle between the center of the elemental field of view of channel 1 in the 130°, 180°, and 230° rotational angle positions and a plane normal to the scan axis shall not vary by more than ± 0.05 milliradians. The worst case misalignment between the scan axis and the optical axis shall be no more than 8 milliradians. Rotational angles are measured in the direction of the scan from the zenith direction. The angular position of the scan axis with respect to the mounting plane and mounting hole pattern of the instruments baseplate shall not change by more than 0.5 milliradian as a direct result of all environmental tests.

7.1.4.2.1. Space Scan

The radiometer scans through a portion of space before scanning the earth. This portion of the scan is used to establish a zero radiance level for clamping the electrical signal of all channels. An unobstructed view shall be provided both by the radiometer housing and the spacecraft for the range of scan angles from the deep space region through the earth scan region.

7.1.5. Optical Alignment

7.1.5.1. Scanner Alignment

A method shall be provided for measurement of the alignment of the AVHRR/3 scan axis and nadir location with respect to up to three external reference surfaces on the instrument frame. The alignment of the instrument scan axis and nadir location to the instrument alignment mirror references shall be measured with an accuracy of ±0.1 milliradians.

7.1.6. Alignment Mirrors

Two small alignment mirrors shall be supplied and permanently attached, one on the earth-facing panel, and the other on the scanner support. See GSFC document Alignment Mirror Adhesive Evaluation, X-722-77-14, dated January 1977 for more information on adhesives for these mirrors.

These mirrors will be used to boresight the AVHRR/3 to the spacecraft and must be located in a convenient position for this purpose. The measurement of the scan axis and nadir location alignment with the mirrors shall have an accuracy of ±0.1 milliradian.

7.1.7. Channel Registration

7.1.7.1. Registration of the Elemental Field of View

At the nadir scan position; the registration of the elemental field of view of all channels shall be within 0.10 milliradians when the radiator temperature is at its predicted nominal in-orbit temperature.

7.1.8. Witness Mirrors

One mirror shall be mounted on each AVHRR/3 at all times during testing in a position to be determined mutually by the contractor and the GSFC T.O. At appropriate times the witness mirrors will be removed and examined for contaminants, etc., during which time an alternate witness mirror will be mounted on the instrument. Analysis of the mirrors will be government furnished.

7.1.9. Solar Input

Under certain spacecraft attitudes, the radiometer may scan through the sun on several successive scans, once per orbit. The radiometer shall be capable of scanning direct solar input without damage or reduction in lifetime. The radiometer shall return to its calibrated condition within one revolution of the scanning system after exposure to the sun.

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8. THERMAL REQUIREMENTS

8.1. GENERAL

This section outlines the thermal design approach and interface requirements necessary to achieve proper thermal control of the instrument.

8.1.1. Spacecraft Thermal Interface

The AVHRR/3 will be mounted on the spacecraft Instrument Mounting Platform (IMP) but shall be independent of the spacecraft interface to the fullest extent possible. The AVHRR/3 shall be in thermal contact with the IMP through the mounting feet only, and the design shall be such that under operation in the mission mode there will be no net heat flow between the IMP and AVHRR/3.

8.1.1.1. Active Thermal Control

The thermal design of the instrument shall utilize to the fullest extent heat transfer through the louver to space for thermal control.

A louver assembly mounted on the spacecraft -X side of the IMP will be used for temperature control. The louver control sensor and heater will be mounted on the AVHRR/3 baseplate. Heater power may be required for operation in the mission mode, (but, in that eventuality, it must be counted as part of the AVHRR/3 power budget) and is also available for louver failure (open), instrument operation in the standby mode or launch mode. The total heater power available in any operating mode shall not exceed the total average power budget less the power dissipation in that mode. This heater will be enabled by the spacecraft command and controlled by the TCE. Its capacity is determined to be sufficient to maintain the instrument at +13°C when it is powered-down and under worst-case thermal conditions.

A dual Temperature Control Electronics (TCE) unit will be used to control heater and louvers. Additional radiator areas on other surfaces of the instrument may be used if necessary.

The IMP will be temperature controlled to 15°C$\pm$1.5°C at the TCE sensor location. The AVHRR/3 temperature set point Ts shall be 15$\pm$1°C. The $\pm$1°C uncertainty is the allowable tolerance on the TCE sensor by the actual value will remain unknown until test. However, once established, Ts will not change.

8.1.1.2. Passive Thermal Control

The conductive heat transfer through the instrument mounting flanges shall not be used as the primary heat flow path. However, in the event of TCE failure, heat from the AVHRR/3 will be conducted through the AVHRR/3 mounting feet, through the IMP to the louver bimetallic springs. Under these conditions, T between louvers fully open and louvers fully closed will be approximately 10°C. In the failure mode the louvers will start to open when the TCE sensor on the instrument baseplate is approximately 2°C above its normal opening point. The geometry of the instrument mounting feet shall be configured to provide minimum contact area of 1.0 sq in. (6.45 cm^2) per foot. For instrument thermal analysis the following joint conductance values should be used: Bare metal joints 0.078 W/°C/cm^2, and RTV Filler 0.31 W/°C/cm^2.

8.1.1.3. Environmental Fluxes

During the launch and orbital acquisition phases, the instrument will be exposed to launch vehicle shroud heating, aerodynamic heating and Sun angles different from those expected during the orbital phase. In addition, there may be a period of time before turn-on when the instrument is fully eclipsed.

8.1.2. Design Requirements

8.1.2.1. Nominal Operating Temperature and Relative Humidity Range

The AVHRR/3 shall meet all performance requirements of this specification in the nominal temperature range of 10°C to 30°C as measured at the baseplate. This temperature range is derived from the operating temperature of the IMP. The thermal design shall be adequate to maintain the AVHRR/3 within these temperature limits when operating in the mission mode. However, these numbers are not rigid. The contractor can open his nominal temperature operating range if thermal design considerations require it. But the unit must be calibrated and operate within specification over the entire range.

The radiometer optical coatings shall be designed to withstand exposure to a relative humidity of 95 percent at 30 degrees C for 24 hours. The instrument shall also be designed to withstand operation in an environment whose relative humidity may vary from 25 to 80 percent.

8.1.2.2. Survivable Temperature Range

The AVHRR/3 shall be built to survive periods in orbit during which the instrument will be in the standby mode, i.e., OFF. It must survive temperature extremes of -5° and +30°C without degradation or failure. However, at these extreme temperatures the instrument need not perform within specification.

8.1.2.3. Standby and Launch Phase Mode Heating

The contractor shall provide a TCE heater, attached to the instrument baseplate, which will operate from the spacecraft +28v TCE bus. This heater is required to keep the instrument temperature as close to Ts as possible and can be used in all operating modes as required, provided its power dissipation is included in the instrument's total power budget.

The contractor shall install one spacecraft contractor-provided thermistor on the baseplate inside each instrument and connect it to the dedicated TCE sensor/heater connector.

8.1.2.3.1. Standby TCE Heater Power

The TCE heater power is furnished by the spacecraft to power the TCE thermal "make up" heater. A separate dedicated connector shall be used on each instrument for connection to the baseplate temperature control sensor and TCE heater. Heater power will be applied with pulsewidth modulated +28 volt pulses as follows:

Pulse Repetition Rate:	5 - 50 Hz
Rise and fall times:	Not less than 0.5 milliseconds
TCE Heater Power:	25 watts

8.1.3. Thermal Analysis

The contractor shall be responsible for the thermal design of the instrument for all phases of flight. The contractor shall provide a thermal Interface Control Drawing and a reduced thermal model, if instrument improvements warrant so, which shall be forwarded for use to the spacecraft contractor via the Technical Officer. The requirements for the reduced thermal model are:

1. The model shall be less than 20 nodes.

2. The mounting feet and mounting surface adjacent to the spacecraft shall be included as nodes.

3. The reduced nodes shall be in tabulated form with the following minimum data for each node:

    a. Conductive and radiative couplings.

    b. Power dissipations, a power profile shall be included that contains maximum and minimum powers under all modes of operation.

    c. Thermal capacity.

    d. Heat absorbed by each external node (Sun, albedo, Earth IR) versus Sun angles and orbit times for at least the 0°, 28°, 68° and 80° Sun angle orbits.

    e. Surface areas, absorptances, emittances and external radiative couplings for all external nodes.

   The instrument designer shall validate the reduced thermal model by making comparisons with his full-sized thermal model for at least 3 steady-state and 3 transient computer runs. The mean internal temperatures resulting from both models should agree within 3°C. The heat transferred to or from the spacecraft should agree within approximately 1/2 W.

   One of the computer runs shall be included in the data package.

8.1.4. Radiant Cooler

The contractor shall use a radiant cooler to cool detectors which must operate at 105°K. The cooler shall be mounted on the anti-sun side of the spacecraft and shall have a hemispherical clear field-of-view to cold space except for the cone subtended by the earth. The cooler must be shaded from earth radiation. The cooler shall use a protective door which will use spring force to open on command from the ground. During acquisition the cooler field of view can sweep through the sun at a rate of 0.5 rpm for an indefinite period of time. The cooler must operate with no degradation after this direct solar impingement. The temperature of the IR detectors shall be actively controlled to 105°K. The instrument design shall provide for in-flight measurement of the cooler parameters to verify performance.

1. Cooler Door Subassembly The cooler door shall be closed during the launch phase and shall be opened permanently upon ground command once a stable orbit has been achieved.

2. Outgassing Heaters The cooler shall be fitted with outgassing heaters which shall be capable of heating the patch to 303^0 K$\pm 2^\circ$ with the door closed.

3. Cooler Door Bumpers Viton bumpers used to provide a soft contact between the cooler door and the cooler assembly when the door is closed shall be domed or chisel shaped where they contact the mirrored surface of the door to minimize their sticking to the door.

8.1.5. Thermal Blankets

The contractor shall be responsible for the design of and shall supply any and all thermal blanketing which may be required including any additional blanketing to interface with the spacecraft blankets which may be required if the instrument extends beyond the spacecraft IMP.

8.1.5.1. Thermal Blanket Standoffs and Clips

The contractor shall provide thermal blanket standoffs attached to each instrument compatible with the dimensions (TBD) required by the spacecraft contractor. Appropriate quick-disconnect blanket retaining clips shall be provided.

9. CALIBRATION AND FLIGHT QUALIFICATION REQUIREMENTS

9.1. GROUND SUPPORT EQUIPMENT REQUIREMENTS

The AVHRR/3 Ground Support Equipment (GSE) shall comprise the unique equipment required to test, check and calibrate the AVHRR/3 as well as all equipment required for spacecraft integration, functional operation and checkout during spacecraft system level testing. GSE shall include chamber test equipment. The GSE from contract (NAS5-30384) shall be reused, modified or replaced where applicable for use in the AVHRR/3 instrument assembly and test, both at the contractor's and spacecraft contractor's plants. This equipment, currently accounted for under NAS5-30384 and located at the contractor's plant, shall be made available to the contractor for use on this contract as Government Furnished Equipment (GFE). The contractor shall maintain this equipment and keep it in proper calibration.

9.1.1. BCU Computer System

The AVHRR/3 Bench Check Unit (BCU) which was refurbished and modified under contract NAS5-30384 shall be used for this procurement. The BCU shall use interface circuits identical to those on the spacecraft.

9.1.1.1 Requirements

The BCU shall have the capability of providing uninterruptable power to the STC computer to preclude loss of data maintenance functions during power interruptions.

9.1.2. NOAA Calibration Tapes

Instrument calibration data shall be generated on CD ROM in the same binary/decimal/ASCII format as was provided for K, L, M. This data shall be included on the CD ROM with the Alignment and Calibration Handbook as specified in paragraph 11.4.4.

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9.1.3. Data Archive

The original calibration data tapes shall be archived at the contractor's plant.

9.1.4. Tape Description

The contractor shall document a complete description of tape types, formats, record sizes, number of records, number of files and the number of records per file, data format and contents in the Alignment and Calibration Handbooks.

9.1.5. Software

The contractor shall provide all required in-plant computer programs which will be used for instrument operations, processing and interpretation of the test and calibration data.

9.1.6. Data Communications

Capability to transfer instrument data to and from the contractor's facility via telephone or diskette shall be provided, using an IBM AT compatible computer system.

9.1.7. Bench Cooler

The Bench Cooler used on the AVHRR/3 program and currently accounted for under NAS5-30384 will be GFE'd to the contractor for use on this contract. The Bench Cooler is fabricated such that it will allow the radiant cooler to operate on the bench at its nominal control point of 105.0°K. This unit will be used at the contractor's facility to perform appropriate instrument checks outside the vacuum chamber.

9.1.8. Ambient Stimuli Equipment (ASE)

The Ambient Stimuli Equipment (ASE) and the ancillary equipment used with the bench cooler, previously used on the AVHRR/3 program and currently accounted for under NAS5-30384 will be GFE'd to the contractor for use on this contract.

9.1.9. Chamber Test Equipment

9.1.9.1. General

The two sets of chamber test equipment used on the AVHRR/3 program will be Government-furnished to the contractor for use on this contract. Each set consists of one variable controlled "Earth" blackbody target, one fixed "Space" blackbody target, one "Visible" target, one controller for targets, one Radiant Cooler cold sink assembly with cryogenic controller, mounting hardware, and cabling. The second set of chamber test equipment, except for cryogenic controller, is at the spacecraft contractor's facility for all spacecraft level tests.

A third set of chamber test equipment shall be produced by the instrument contractor for use at the METOP facility.

The contractor shall review the performance of the chamber test equipment sets and make modifications required to closely simulate the range of orbital conditions which the instruments would expect to see in orbit.

9.1.9.2. Blackbody Calibration Targets

These blackbodies shall be used at the contractor's plant to provide the baseline calibration of the AVHRR/3 which will be used to demonstrate the flight worthiness of the instrument and to calibrate the on-board blackbody target. Actual in-flight calibration will be accomplished by the on-board target and space. At the spacecraft contractor's facility, the second set of targets will be used in thermal/vacuum testing to check the instrument calibration.

9.1.10. Target Temperature Control Unit

9.1.10.1. General

The two control units for the Earth blackbody targets used on the AVHRR/3 program will be Government-furnished to the contractor for use on this program. The control unit is designed to drive resistance type heaters operating against a liquid nitrogen (LN_2) or cooled brine heat sink.

9.1.10.1.1. Control Console

The target consoles controlling the variable target used on the AVHRR/2 program will be Government-furnished to the contractor for use on this program. They control the targets independently and have independent digital temperature readout equipment.

9.1.10.1.2. Cables

The cabling required for operation of the control consoles including those cables with the console to the spacecraft contractor's facility which were used on the AVHRR/3 program will be Government-furnished to the contractor for use on this program.

9.1.11. Optical Bench Test Facility

The optical bench used for performing the instrument alignment and alignment checks as well as all the required optical tests on the AVHRR/2 program will be Government-furnished to the contractor for use on this program.

9.1.12. Ground Support Equipment Tests

The contractor shall design and perform tests to demonstrate that the GSE is functioning properly and within specification.

9.1.13. Limits Computer Software Program

The contractor shall utilize the program which was developed under NAS5-30384 to monitor all functions of the AVHRR/3 on a real-time basis. Certain functions shall be designated as critical, and the program will be designed to notify the operator if these become out-of-limits. The program shall be designed to verify all operational modes of the scan and print out any out of tolerance items. This program will normally be used during acceptance thermal-vacuum testing of the flight models. It will be used anytime the instrument is being operated from the Bench Check Unit.

The contractor shall use the program to thoroughly check the subsystem data outputs. It will be used to detect intermittent operation and failures during extended periods of automatic system operation with constant stimuli. It will continuously monitor all prime data, verify that they remain between present limits, and check format, sign and parity. It will log all discrepancies detected using the printer and will notify the operator in case of critical failures.

9.2. SYSTEM PERFORMANCE TEST REQUIREMENTS

9.2.1. General Requirements

The contractor is required to demonstrate by practical test and calibrations that the items produced under the contract meet all the requirements of this specification. He will, as a minimum, perform the tests and calibrations outlined below.

9.2.2. Required Tests

The required tests for each flight instrument shall, as a minimum, include the following:

1. Instantaneous field of view and channel registration.
2. Environmental tests.
3. Modulation transfer function.
4. Spectral response - all channels.
5. NEDT in channels 3B, 4 and 5.
6. Signal to noise in channels 1, 2 and 3A.
7. Jitter and synchronization drift (Sync. Delta).
8. Calibration

   a. IR channels - Shall be calibrated at five base plate temperatures.

   b. Visible channels - Shall be calibrated at room temperature. In addition, relative visible response measurements shall be made in thermal/vacuum.

9. Pictorial Display - Coherent Noise.
10. Exercise all commands.
11. Operate with all possible voltage inputs.
12. Check on all telemetry points.
13. Check all redundant aspects of the instruments.

9.2.3. Environmental Test Requirements

The AVHRR/3 instruments shall meet the environmental requirements specified in the AVHRR/3 and HIRS/3 Performance Assurance Requirements document, S-480-29.

9.2.3.1. Post-Vibration Measurements

The following measurements on the assembled instrument shall be made after vibration testing is completed.

1. The pitch and roll alignment of the instrument's nadir direction with respect to the external reference mirrors.
2. The yaw alignment of the scan axis with respect to the external reference mirrors.
3. The accuracy of the measurements shall be within 0.05°.

9.2.3.2. Channel Axes Alignment

Alignment of the axes of the six channels shall all remain within 0.1 (with a goal of 0.05) milliradians with respect to one another after environmental testing at the qualification or acceptance levels.

9.2.3.3. Test Plan and Procedures

9.2.3.3.1. Test Plan

The Test Plan will be an updated version of that used for the AVHRR/3, reflecting those changes to the instrument specification requiring revised or additional testing, plus RFI testing.

9.2.3.3.2. Test Procedure

A Test Procedure shall be a step-by-step instruction for performing an alignment, calibration or test outlined by the Test Plan. It shall specify the environmental conditions for the test, the tolerance on all input stimuli, the limits on the output performance and the pass-fail specifications. Each Test Procedure shall indicate all changes made to it after it is initially issued. It shall be submitted to GSFC for approval four weeks before the test of the first flight unit.

9.2.4. Documentation of Tests and Calibrations

The contractor shall document the results of all tests into Test Reports (referred to as "Verification Reports" in the performance assurance document) which shall be submitted within one month after instrument delivery. He shall also document results in Alignment and Calibration data books which shall become a record of all tests which could aid in interpretation of the orbital data, and all calibrations made for the instrument. A summary section shall be prepared for each record book which contains functional equations and charts depicting the final calibrations of the instrument and every other subsystem output as determined from all tests performed.

Also required are normalized albedo, radiance and equivalent blackbody temperatures for calibrations.

9.2.5. Performance Checks

The contractor shall conduct appropriate performance checks of the instrument immediately before and after each of the qualification or acceptance tests specified.

9.2.6. Retesting

In the event of a failure during qualification testing or acceptance testing, the contractor may be required to rerun the complete test starting at the beginning of whichever test the failure occurred. The exact nature of retest shall be determined jointly by GSFC and the contractor.

9.2.7. Electromechanical Design Tests

The contractor is required to submit a test plan for verifying the flight worthiness of any subassembly which has changed significantly from the AVHRR/2 configuration, or from the previous AVHRR/3 configuration. If a special model is constructed for a specific test, as for example, a subassembly vibration test, it must be identical to the proposed flight subassembly, and all operating parameters shall conform to this specification.

9.2.8. Subsystem Board-Level Electronic Test

For each board-level assembly the contractor shall perform laboratory tests of the drift, linearity and gain stability of the analog and/or digital signal electronics at, 50°C, 0°C and ambient.

9.2.9. System Optical Tests

The contractor is required to design a test to perform and check the optical alignment of the system. This test shall be part of a general optical and electrical performance test which shall be performed before and after any test that might change the optical alignment; e.g., the vibration test.

9.2.10. Thermal/Vacuum Testing

The flight acceptance thermal/vacuum profile is shown in figure 8.

9.2.11. Instrument Shutdown and Re-start Tests

1. With Thermal Control Heaters System shutdown and restart in orbit shall be simulated. At the 15°C plateau the instrument will be shut down and temperatures allowed to stabilize before the instrument is restarted. The thermal control heaters will be used here. Once all temperatures are stabilized, the unit will be restarted and warm-up time measured.

2. Without Thermal Control Heaters Same as above except thermal control heaters will not be turned on. Final temperature shall be determined along with warm-up time. Care should be taken to see that the unit temperature does not go below a safe level below the predicted launch cold case.

9.2.12. Pictorial Display

A two-dimensional pictorial display shall be produced from each channel using a worst-case scene to determine the existence of coherent noise. The picture shall be constructed by filling the full dynamic range of the display with a maximum of 18.2% of the dynamic range of the instrument. The 18.2% of the instrument signal shall be taken from that portion of the dynamic range which exhibits the worst coherent noise features. The vertical axis of the display equipment may be driven to produce the two-dimensional display from a fixed one-dimensional repetitive scan.

An alternative method of testing for coherent noise in each channel of the instrument may be used with the approval of the GSFC T.O.

9.2.13. Trouble-Free Performance Testing

By the conclusion of the environmental test and calibration program, the instrument shall have operated for at least 50 hours trouble-free.

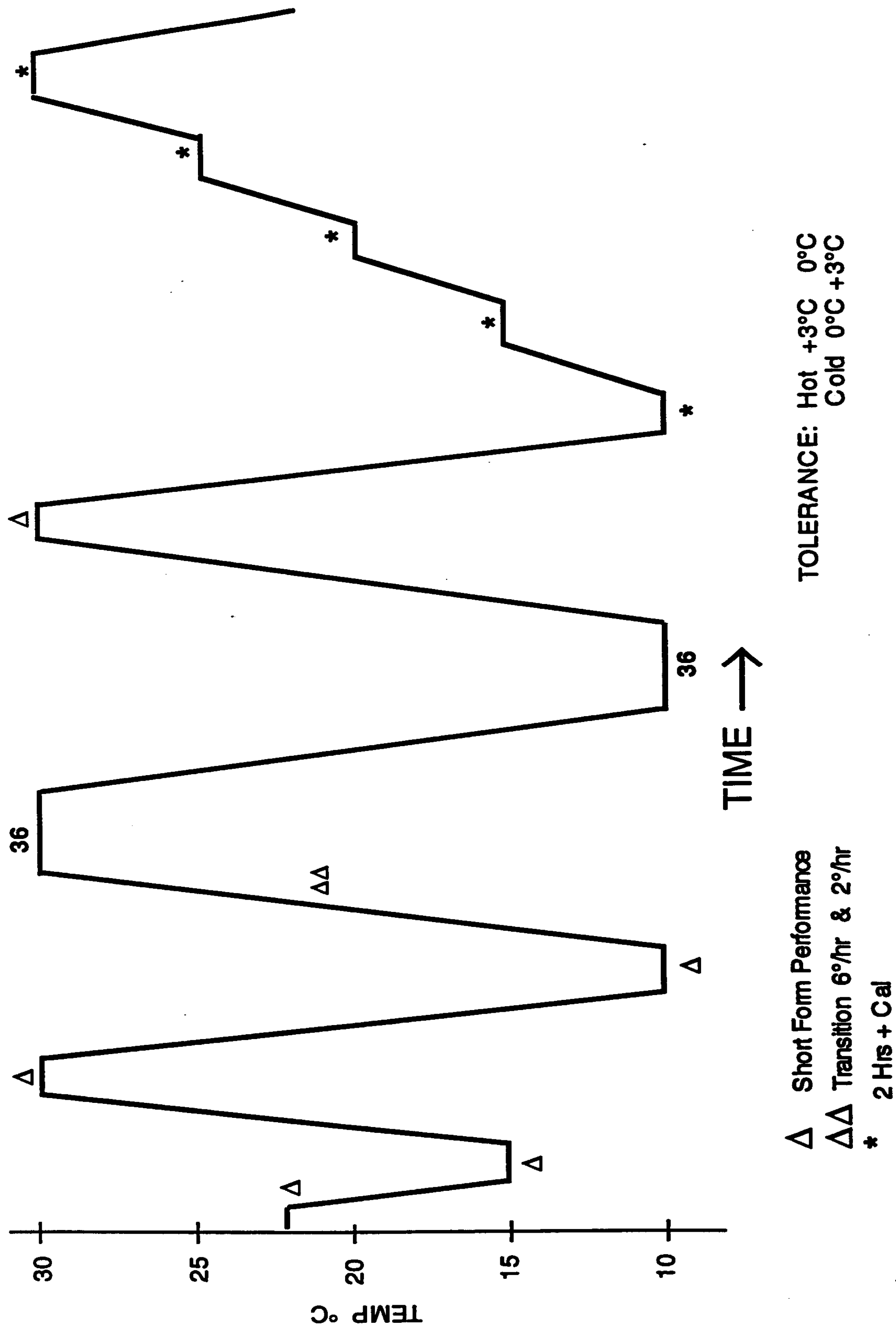

Figure 8. Flight Acceptance Thermal/Vacuum Profile

9.3. SYSTEM CALIBRATION TEST REQUIREMENTS

9.3.1. General

The determination of channel output vs. input scene radiance (albedo) for each spectral region for each of six channels will be the most comprehensive test of the system design and performance. This test must be capable of producing the information needed for processing the data gathered in orbit. The calibrations will be planned to demonstrate subsystem performance and provide a calibration of the spectral radiances of the on-board blackbodies with an external blackbody as reference measured within $\pm 0.5^{\circ}K$ over the temperature ranges of the external blackbody targets.

It is required that all temperature and voltage monitors be calibrated. Equations as well as data tables shall be provided for all monitors as a function of the AVHRR/3 output.

9.3.2. Results of Calibrations

The results of the calibrations shall be summarized by the contractor in the Alignment and Calibration Data Book. The information listed below shall be derived from the calibration data:

1. NEDT - Noise equivalent temperature difference for measurements in each channel.

2. Standard deviation of individual calibration points from the best fit calibration curves for each channel and each calibration.

3. Calibration of in-flight calibration blackbodies in terms of effective temperature versus temperature monitor bit outputs.

4. Calibration curves of all thermistors.

5. Calibration of all voltage monitors.

6. Calibration of all platinum resistance thermometers (PRT).

9.3.3. Response Calibrations

The contractor shall calibrate and test the instrument and/or perform calculations as approved by the GSFC T.O. to determine the response calibrations and all significant corrections to those calibrations for the full expected range of instrument interface temperatures, detector temperatures and scan angles. The effective temperature of the in-flight blackbody shall be determined as a function of its temperature monitor outputs by comparison with external calibration blackbodies. The contractor shall plan and conduct a test program which will produce the information required to evaluate the orbital measurement with a (NEDT) precision equal to or less than the required values.

The calibration plans shall include the items outlined below, but need not be limited to them. The calibration environment for the instrument shall simulate the mean mission thermal radiation environment. The instrument shall be tested with its full complement of shields and insulation.

9.3.3.1. IR Channel Calibration Requirements

Radiance response calibrations and calibration checks of the IR channels shall be made with the instrument scanning in a normal manner at the following five T/V temperature plateaus: 10°C, 15°C, 20°C, 25°C, and 30°C, within ±1°C. See Figure 8. for the flight acceptance thermal/vacuum profile. At each temperature plateau, the external calibration target shall be cooled to 180°K at the start of calibration and calibration runs made at 180, 220, 240, 255, 265, 275, 285, 290, 295, 300, 305, 310, 315, 320, 325. 330, and 335°K. The target temperature shall be set to its preselected value ±1°K and stabilized sufficiently to meet target temperature requirements. The target temperature is determined from the mean of the several PRT's imbedded in it. During the period that calibration data are taken, the indicated target temperature change of each platinum sensor taken individually shall be less than 0.1°K. In other words, if any platinum sensor indicates a target temperature change of 0.1°K or greater during the calibration run, all data for the run will be discarded. At least 200 samples of calibration data will be taken for each channel at each target temperature at each instrument plateau.

9.3.4. Special Thermal/Vacuum Data Requirements

During the calibration portion of the instrument thermal/vacuum acceptance test, a separate data tape will be prepared either from the master data tape or from a separate simultaneous recording. This data tape shall be changed at appropriate places during the thermal/vacuum cycle, (i.e., after the initial cool down, after each calibration plateau, etc.) and copies forwarded in a timely fashion to the GSFC T.O.

9.4. INSTRUMENT TEMPERATURE AND VOLTAGE MONITOR CALIBRATION

9.4.1. Temperature Sensor Calibrations

9.4.1.1. Temperature Circuit Calibrations

The contractor shall use thermistors that have a 0.5 percent interchange ability. The contractor shall use 0.1 percent tolerance resistors in the thermistor circuits, and the circuit voltages shall be regulated and read out. Calculated calibrations for each type of thermistor circuit shall be furnished. Those read out as spacecraft analog data shall be calibrated in terms of volts versus temperature. The thermistor circuit shall provide maximum resolution over the expected operational temperature range.

9.4.1.2. Platinum Resistance Thermometer Calibrations

The contractor shall provide calibrations of the platinum resistance thermometers (PRT). Prior to the final assembly of the AVHRR/3, each platinum resistance thermometer output shall be calibrated over the worst case temperature range at which it is expected to operate. A transfer standard will be used for system calibration. Temperature precision shall be better than ±0.1°C with a goal of ±0.05°C.

9.4.1.3. Platinum Resistance Thermometer In-Circuit Calibrations

The contractor shall furnish in-circuit calibrations of the PRT circuits in terms of volts and counts versus PRT resistance and will calculate and measure the calibration for each PRT in its circuit in terms of volts and counts versus temperature (°C).

9.4.2. Voltage Monitors

The contractor shall determine and furnish calibrations for the spacecraft analog voltage monitor circuitry in terms of volts.

10. PROGRAM SUPPORT REQUIREMENTS

10.1. PROGRAM REVIEWS

The contractor shall conduct the following reviews:

1. Preliminary Design Review - For new or modified elements of the program, this review usually occurs early in the design phase but prior to manufacture of engineering hardware.

2. Critical Design Review - For new or modified elements of the program, this review shall occur after the design has been frozen but prior to the start of manufacture of flight components. It will emphasize implementations of design as well as test plans for flight systems including the results of engineering model testing.

3. Pre-environmental Review - This review shall occur prior to the start of environmental testing of the proto flight or flight system. The primary purpose of this review is to establish the readiness of the system for test and evaluate the environmental test plans.

4. Pre-shipment Review - This review shall take place prior to shipment of the flight instrument to GE/AE, and will concentrate on system performance during acceptance testing. The review shall cover all of the test data, the quality and reliability actions, the Configuration Management Records and the MR actions. All of the action items resulting from this review must be completed before the DD250 document is signed.

10.2. MONTHLY PROGRESS REPORT

The contractor shall submit a written weekly progress report. It shall be submitted electronically to a GSFC supplied distribution list. The report shall include instrument status on all instruments currently undergoing manufacturing or testing at the contractor facility. Instrument status should include the past week's accomplishments, the next week's planned activities, any open incident reports existing on that instrument and should track progress against major schedule milestones, including current projected instrument delivery dates. Status of pertinent issues shall also be reported. They include, but are not limited to, open issues concerning the instruments delivered to the MetOp Program or the instruments involved in POES Spacecraft integration and testing.

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The following tables or charts shall also be included.

1. Incident report status showing the total number of open incident reports.
2. Technical action item list and status.
3. Calendar of the present month and following month showing significant events.
4. Business action item list and status.
5. Proposal status detailing contractor status of proposals and Support Orders.
6. Configuration Management status of open paper work.

When no instrument is in manufacturing or testing at the contractor's facility, the weekly report will be substituted with a monthly report of similar content.

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10.3. CONFIGURATION MANAGEMENT

10.3.1. Program and Plan

The contractor shall maintain and implement a Configuration Management Program similar to and in accordance with ITT Document No. CMP-16603.

The Configuration Management system shall be maintained throughout the life of the AVHRR/3 contract. It shall provide:

1. The capability of accounting at any one time for the actual firm design in existence.

2. An orderly and well defined method of implementing and documenting approved changes.

3. GSFC review and/or approval of proposed changes.

10.3.2. Classification of Changes

Proposed changes which require either review or approval by the GSFC TIROS Project Configuration Control Board (CCB) shall be classified as follows:

1. Requires GSFC Approval

Class I change - Any change which impacts the GSFC TIROS Project's technical performance requirements, technical interfaces, cost or schedule requirements.

2. Requires GSFC Review

Class II change - A change shall be classified Class II when it does not fall within the definition of a Class I change. Examples of a Class II change are:

A change in documentation only (e.g., correction of errors, addition of clarifying notes or views); or change in hardware (e.g., substitution of an alternative material or "make play" changes) which does not affect any factor listed under Class I changes.

Class I changes originated by contractor shall be documented on a TIROS Configuration Change Request, GSFC 480-39, and submitted to the GSFC TIROS Project CCB for approval prior to implementation.

Class II changes originated by the contractor, and approved by the contractor's CCB shall be submitted on the contractor's internal change forms for GSFC review. Class II changes do not require GSFC concurrence prior to implementation.

10.3.3. Configuration Management Documentation

Configuration management program status reports shall be submitted by the contractor as part of the monthly progress report. Documentation shall be submitted in accordance with Appendix B of the Statement of Work, S-480-35 subject to actions by GSFC as indicated.

10.3.4. Schedule Reporting Requirement

The contractor shall establish and maintain a schedule control system which shall meet the following requirements:

The scheduling system shall show the authorized work in a manner which describes the sequence of work and identifies the interdependencies required to meet the development and delivery requirements of the contract. The format shall be in accordance with the Work Breakdown Structure, the system and the resolution of the schedule events shall be detailed enough to include printed circuit boards and parts of each of the major subassemblies (but not including electronic piece parts).

Each event shall include:

1. The actual starting date.
2. The original planned starting date.
3. The current completion estimate.
4. The actual completion date.

Shaded event indicates that it is complete. This system shall provide monthly status reporting and the contractor shall submit for approval a development and delivery schedule broken down by instrument as indicated in the Work Breakdown Structure.

The monthly update report shall revise each appropriate schedule event and shall commence one month after contract award.

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11. DOCUMENTATION, MANUALS, AND PROCEDURES

11.1. DOCUMENTATION FORMAT

Unless otherwise specified, all documentation delivered to NASA by the Contractor shall:

1. Be reproducible.

2. Be bound in such a fashion that it is easy to disassemble for copying.

3. All drawings or graphs included in documents shall be reduced to 8 by 11 inch size with or without foldouts. All drawings and graphs shall be titled and dated.

4. Every page, beginning with the cover, shall be identified with a document number or name, sequentially numbered, show total pages of the document and dated in a manner similar to that done on this specification.

5. The front cover of all documents shall contain:

   A. The document title.

   B. The NASA Contract Number and the GSFC mailing address of the Technical Officer responsible for this contract.

   C. The name, mailing address and telephone number of the contractor.

   D. The publication date of the document.

11.2. MANUALS

11.2.1. AVHRR/3 Technical Description

The contractor shall prepare and deliver the AVHRR/3 Technical Description Document in accordance with that required by the contract.

11.3. GSE INSTRUCTION MANUALS

The contractor shall deliver GSE Instruction Manuals in accordance with that required by the contract.

11.4. TEST AND CALIBRATION DOCUMENTATION

11.4.1. General

The contractor shall prepare and deliver where applicable a comprehensive set of test procedures for the system, subsystem and GSE equipment. Updated versions shall be provided as required.

Instrument performance documents delivered to the government (e.g. "Alignment and Calibration Documentation Books") and each graph and table within them shall indicate the date of the measurement and the date of the data analysis, as well as the names of the people who performed the measurement and analyzed the data.

11.4.2. Test Reports

The contractor shall prepare and submit Test Reports in accordance with PAR appendix C, for each instrument documenting the results of the test/measurements specified in the Test Plan. These reports shall be typed, approved by the Contractor's Project Manager and verified by QA. They shall describe the test and any differences from the prescribed test procedures, test results, data and/or dated references to data sources and conclusions as to the instruments flight worthiness.

11.4.3. Engineering and Design Tests

The results of any tests that might be required to prove a design concept or might otherwise be termed an engineering test shall be incorporated into Engineering Test Reports and delivered in accordance with appendix C of the PAR.

11.4.4. Alignment and Calibration Documentation

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All alignment and calibration data shall be incorporated into an Alignment and Calibration Data Book, and as applicable, on CD ROM.

The Alignment and Calibration Data Book shall contain, in addition to other data, a table of channel numbers and corresponding spectra, the FOV plots of each channel, the calibration curves, algorithms and original data used to derive them, of all temperature sensors and the best fit radiometric calibration curves and algorithms. Calibration documentation shall be sufficient for independent verification by the government of the contents of the alignment and calibration book and shall include copies of the computer printout from which the calibration curves are drawn.

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At a minimum, the following information shall be included in the Alignment and Calibration books and on CD ROMs in ASCII format:

1. Radiance Calibration. This shall be plotted as radiance vs. counts with the non-linear temperature scale shown on the radiance axis. A tabular listing of the data from which these curves are constructed shall also be provided.
2. Calibration curves and algorithms for all telemetry points.
3. Spectral characteristics of all channels, plus the raw data from which the curves were generated.
4. Graph of the field of view.
5. MTF data.
6. Alignment of scanner fields of view with respect to the radiometer reference mirrors.
7. Final Acceptance Test Data (this shall include all data required to verify performance).
8. Radiance to counts tables for all channels; normalized albedo to counts tables for channels 1, 2 and 3A; and equivalent blackbody temperature to counts tables for channels 3B, 4 and 5.

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One CD ROM shall include the Microsoft Word version of the Alignment and Calibration Handbook, the NOAA Calibration Data as described in 9.1.2, and the electronic Optical Data as described above. Any update to any of these deliverables shall result in a resubmittal of all deliverables on the CD ROM.

11.4.5. Instrument Log Book

An instrument log book shall be maintained at the contractor's facility which shall contain a chronological record of all instrument activity beginning at completion of system integration and continuing up to instrument delivery. This log will be a permanent record of all events pertinent to the unit including all planned test activity, all engineering test activity which might be required because of anomalous operation, all malfunction report activity and the total instrument operation time.

This record shall be kept current at all times and shall be available for review at any time by any authorized NASA or NOAA representative.

11.4.6. Full Size Drawings

The Contractor shall from time to time make copies of specifically requested full size drawings and mail them to the GSFC Technical Officer. A total of up to 200 separate drawings may be requested over the period of performance of this contract.

11.4.7. Reduced Size Drawing Books

The Contractor shall provide 4 copies of a separate, reduced size drawing book with drawings reduced in size to 8 x 11 inches with fold-outs, as required, of all electrical schematics and selected by the GSFC Technical Officer mechanical assembly drawings one month after CDR. The Contractor shall provide updated reduced size drawings as required.

11.4.8. Photographs

The Contractor shall supply 6 sets of 8" x 10" glossy color photographs of all instruments and ground support equipment covered by this contract to the GSFC Technical Officer. Each set of instrument photographs shall record views of the finished instrument from at least three most descriptive angles with the cooler door opened and closed and the scan mirror in different positions where it may be seen in different pictures. There shall be an appropriate number of instrument-disassembled and partially assembled pictures. Pictures shall be numbered, titled and dated on the back of each one. One each, numbered, color negatives shall be provided for each of the different delivered pictures.

11.4.9. Deliverable Documentation and Equipment

The Performance Assurance Requirements Appendix C, and the Statement of Work, S-480-35, describes the required deliverable documentation and equipment.

11.4.10. Interface Document

The interface documents defining the electrical, mechanical, and thermal interfaces of the AVHRR/3 with the NOAA spacecraft are the General Interface Specification, No. IS-3267415 and TIROS Unique Interface Specification for AVHRR, No. IS-20029950. The contractor shall provide updated interface specification information for these documents as required.

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APPENDIX A

GLOSSARY

APPENDIX A

GLOSSARY

ABPL	As-Built Parts List
AC	Actual Cost
ADC	After Date of Contract
AMSU	Advanced Microwave Sounding Unit
AOC	After Award of Contract
ARO	After Receipt of Order
AVHRR/3	Advanced Very High Resolution Radiometer/3
BCWP	Budgeted Cost of the Work Performed
BCWS	Budgeted Cost of the Work Scheduled
BCE	Bench Check Equipment
C	Centigrade
CCB	Configuration Control Board
CDR	Critical Design Review
CM	Configuration Management
CONFIG.	Configuration
CPM	Critical Path Method
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic and Electromechanical (part)
EM	Engineering Model
EMI	Electromagnetic Interference
ETM	Engineering Test Model
FM	Flight Model
GFE	Government Furnished Equipment
GIDEP	Government-Industry Data Exchange Program
GIIS	General Instrument Interface Specification
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HIRS/3	High Resolution Infrared Radiation Sounder/3
IMP	Instrument Mounting Platform
INSTR.	Instrument
K	Kelvin
LSB	Least Significant Bit
MGT.	Management
MRB	Material Review Board
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite, Data and Information Service
NOAA	National Oceanic and Atmospheric Administration
NSPAR	Nonstandard Parts Approval Request
NSPL	NASA Standard Parts List

O&M	Operations and Maintenance
OTM	Optical Test Model
PA	Performance Assurance
PAR	Performance Assurance Requirements
PC	Personal Computer
PDR	Preliminary Design Review
PER	Pre-Environmental Review
PF	Proto flight
PFM	Proto flight Model
PPL	Preferred Parts List
PPS	Pulses Per Second
PRT	Platinum Resistance Thermometer
PSR	Pre-Ship Review
S/C	Spacecraft
SCDR	System Concept Design Review
SCR	System Concept Review
SOW	Statement of Work
STU	Special Test Unit
TCE	Temperature Control Electronics
TM	Telemetry
TMP	Temperature
TO	Technical Officer
TOVS	TIROS Operational Vertical Sounder
u	Micron
UIIS	Unique Instrument Interface Specification
WBS	Work Breakdown Structure

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APPENDIX B

APPROVED DEVIATIONS AND WAIVERS

<table>
<tr><th>Deviation/ Waiver No.</th><th>CCR No.</th><th>CCR Approved Date</th><th>Section/ Effectivity</th><th>Description</th></tr>
<tr><td>W-31</td><td>1123</td><td>09/0/2/92</td><td>Table 4 7.1.2.5(1) - A301, A302, and A303</td><td>This part determines the spectral bandpass of AVHRR/3 Channel 4. The requirement for the 50% spectral points in Channel 4 are 10.3 ±0.09 microns and 11.3 +0.09, -0.13 microns. The parts produced by the vendor have 50% transmission points at about 10.4 and 11.4 microns which would cause the AVHRR/3 to fail the Channel 4 spectral response requirement. The values for each witness sample are as follows:
AVHRR/3 Channel 4/5 Filter/Beamsplitter
<table>
<tr><th>WITNESS</th><th>LOT</th><th>50%</th><th>50%</th><th>5%</th><th>5%</th><th>80%</th><th>80%</th></tr>
<tr><th>SAMPLE</th><th>NUMBER</th><th>UPPER</th><th>LOWER</th><th>UPPER</th><th>LOWER</th><th>UPPER</th><th>UPPER</th></tr>
<tr><td>(MICRON)</td><td>(MICRON)</td><td>(MICRON)</td><td>(MICRON)</td><td>(MICRON)</td><td>(MICRON)</td><td></td><td></td></tr>
<tr><td>W2496A</td><td>2410-01</td><td>11.41</td><td>10.39</td><td>11.6</td><td>10.22</td><td>11.33</td><td>10.48</td></tr>
<tr><td>W2496B</td><td>2410-01</td><td>11.42</td><td>10.4</td><td>11.62</td><td>10.22</td><td>11.33</td><td>10.49</td></tr>
<tr><td>W2496C</td><td>2410-01</td><td>11.44</td><td>10.42</td><td>11.64</td><td>10.25</td><td>11.35</td><td>10.51</td></tr>
<tr><td>W2496E</td><td>2410-01</td><td>11.4</td><td>10.38</td><td>11.6</td><td>10.24</td><td>11.31</td><td>10.45</td></tr>
<tr><td>W2496F</td><td>2410-01</td><td>11.4</td><td>10.38</td><td>11.6</td><td>10.25</td><td>11.31</td><td>10.45</td></tr>
<tr><td>2496-39</td><td>2410-01</td><td>11.41</td><td>10.38</td><td>11.6</td><td>10.24</td><td>11.33</td><td>10.47</td></tr>
</table>
</td></tr>
<tr><td>W-35</td><td>1124</td><td>09/02/92</td><td>7.1.2.1(1)- A301, A302, and A303</td><td>AVHRR/3 Flight Model 301 spectral response in Channel 3B is out of specification. The specified longwave slide slope is 3% or less between the 5% and 80% of peak response points. The actual measured slope is 4%. Reference the figure attached to this waiver.</td></tr>
<tr><td>W-36</td><td>1124</td><td>09/02/92</td><td>7.1.2.4(2)- A301, A302, and A303</td><td>AVHRR/3 Flight Model 301 spectral response in Channel 1 is out of specification. The peak response wavelength is required to be at 630 ±10 nanometers. Actual is 650 nm. Reference the figure attached to this waiver.</td></tr>
<tr><td>W-37B</td><td>1200</td><td>12/13/93</td><td>5.20.2 - A301</td><td>Approval of this waiver will allow acceptance of the FM-301 AVHRR/3 instrument with an out-of-spec condition of radiated EMI (ref.: section 3.6.1.4.2 of IS-3267415, UIIS and section 5.20.2 of S-480-27.3 Rev. B). See memos JB-92-4 dated 3/20/92 and JB-93-20 dated 10/25/93 for details (ref.: FR 10695) attached to waiver.</td></tr>
<tr><td>W-46</td><td>1198</td><td>12/13/93</td><td>7.1.2.6(2) - A301</td><td>AVHRR/3 Flight Model 301 spectral response in Channel 5 is out-of-spec. The slope of the curve (on the LW side of the scan) is required to be less than 4.0 percent. The actual was measured to be 5.3 percent and a remeasurement of 4.4 percent. This out-of-spec condition is due to a slight shift in the 80 percent response point to the short wavelength portion of the curve. See curve and continuation sheets attached to waiver.</td></tr>
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Deviation/ Waiver No.	CCR No.	CCR Approved Date	Section/ Effectivity	Description
W-47	1196	12/13/93	3.2.10 - A301	The width of CH 4's IFOV in the cross-scan direction measures 1.54 mr (spec is 1.30 ±0.20mr). This is due mainly to the use of a marginally wide detector from the Engineering Model AVHRR/3 (which was necessitated by the detector drift issue, ref.: FR10970). Difficulty was encountered during registration to obtain proper focus in this channel and subsequent measurements were marginally within spec. Date — CH 4 Width — Comment 7/21/93 — 1.50mr — Post Acceptance Vibe < IR Gain Retailoring: FR 11015> 8/27/93 — 1.48mr — Pre Workmanship Vibe 9/6/93 — 1.54mr — Post Workmanship Vibe (FINAL)* *This measurement was made using 0.005" micrometer increments on the collimator target assembly (to obtain decent contour plots). The other measurements were made with 0.010" increments which generally result in slightly narrower width calculations due to interpolation. If the 9/6/93 data is re-calculated at 0.010" increments, the width measures 1.51mr. This is within the measurement repeatability error for 0.010" data.
W-45	1199	12/29/93	5.6.3.1A - A301	The Channel 3A endpoint gain adjustment is 6.261V instead of 6.1V, an increase of 2.3% over what is called for in the specification. Since recalibration of A301 is likely prior to launch, this waiver is being requested on the basis that if subsequent visible calibrations indicate further reduction of A/D dynamic range, the gain of Channel 3A can be reduced at that time.
W-35A	1209	01/04/94	7.1.2.4(2) - A301	AVHRR/3 Flight Model 301 spectral response in Channel 3B is out of specification. The specified longwave slide slope is 3% or less between the 5% and 80% of peak response points. The actual measured slope is 4.7%. Reference the figure attached to this waiver. This waiver resubmittal reflects the final A301 test results.
W-49	1208	01/04/94	7.1.2.2.1 - A301	Paragraph 7.1.2.2.1 requires the peak of CH 2's spectral response to be between 0.725 and 0.865 μm (MOD-19). A301 CH 2's peak spectral response measured 0.93 μm.
W-51	1258	02/13/95	7.1.2.2 - A302	The Channel 2 Spectral Response in the AVHRR/3 S/N 302 instrument fails the peak response and shortwave 50% to 80% separation requirements. Page 2 of this waiver details the measured parameters versus the specification requirements. Page 3 indicates the measured spectral response curve and Page 4 lists the relative spectral response data.
W-52	1259	02/17/95	7.1.2.5 - A302	The Channel 4 Spectral Response in the AVHRR/3 S/N 302 instrument fails the longwave slope requirements. Page 2 of this waiver details the measured parameters versus the specification requirements. Page 3 indicates the measured spectral response curve and Page 4 lists the relative spectral response data. Page 5 indicates the predicted spectral response curve.
W-53	1260	02/17/95	7.1.2.4 - A302	The Channel 3B Spectral Response in the AVHRR/3 S/N 302 instrument fails the LW 50% point and LW slope requirements. Page 2 of this waiver details the measured parameters vs. the spec. requirements. Page 3 shows the measured spectral response curve and page 4 lists the relative spectral response data. Page 5 shows the predicted spectral response.

Deviation/ Waiver No.	CCR No.	CCR Approved Date	Section/ Effectivity	Description
W-53	1260	02/17/95	7.1.2.4 - A302	The Channel 3B Spectral Response in the AVHRR/3 S/N 302 instrument fails the LW 50% point and LW slope requirements. Page 2 of this waiver details the measured parameters vs. the spec. requirements. Page 3 shows the measured spectral response curve and page 4 lists the relative spectral response data. Page 5 shows the predicted spectral response.
W-53	1260	02/17/95	7.1.2.4 - A302	The Channel 3B Spectral Response in the AVHRR/3 S/N 302 instrument fails the LW 50% point and LW slope requirements. Page 2 of this waiver details the measured parameters vs. the spec. requirements. Page 3 shows the measured spectral response curve and page 4 lists the relative spectral response data. Page 5 shows the predicted spectral response.
W-53	1317	05/15/95	7.1.2.4 - A303	The Channel 3B Spectral Response in the AVHRR/3 S/N 303 instrument fails the LW 50% point and LW slope requirements. Page 2 of this waiver details the measured parameters vs. the spec. requirements. Page 3 shows the measured spectral response curve and page 4 lists the relative spectral response data. Page 5 shows the predicted spectral response.
W-49A	1326	06/30/95	7.1.2.2.1- A303	Paragraph 7.1.2.2.1 requires the peak of the Channel 2 spectral response to be between 0.725 and 0.865 μm (MOD-19). A301 Channel 2 peak spectral response measured 0.93 μm. A302 Channel 2 wavelength of peak spectral response measure 0.92 μm; A303 Channel 2 peak response was measured at 0.88 μm.
W-60	1326	07/12/95	6.1.13.5- A304 and A305	GSFC-S-480-28.2 paragraph 6.1.13.5 requires the contractor to prepare and furnish materials and process list for materials used. It will categorize all materials listed as metals, plastics, coatings, miscellaneous, and etc., and adequately identify the item the government specification, process, cure cycle, type, chemical composition and/or manufacturer. The listing shall also specify the application(s) of each material in the subsystem. Request acceptance of nondisclosure of proprietary materials (steel alloys) and their corrosion preventative coatings for use defined by SMI assembly drawing 101845 and proprietary fabrication drawings 103408 stator lamination and 103932 rotor lamination which are based on extensive space flight and qualification heritage on previous NASA programs for more than 28 years. Materials & Process Lists which contain these proprietary items have been accepted by other prime contractors and NASA.
W-86	1406	05/09/96	5.16.3- A302	A302 had 27 Mate/Demates on J6 when it was first shipped to LMAS in 3/95. The four month long EMI troubleshooting effort from 10/94 to 1/95 contributed to this large number of Mate/Demates. Twenty-three additional Mate/Demates have occurred on J6 since the A302 was returned for testing per TD48 and regression testing per FR11157.
W-89	1419	08/09/96	5.6.4.1- A301	Waive the endpoint requirements for channels 4 and 5 on AVHRR A301. The requirement is 300 +/-100 mV at 335^{o}K external calibration target and with a 15^{o}C baseplate temperature. The actual endpoints are 87.4 and 112.6mV respectively. The instrument still has sufficient margin where these channels will not saturate on orbit.
W-98	1505	10/16/97	5.16.3 - A302	Waive the requirement to limit the number of Mates/Demates for A302 to 30.

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W-97	1511	11/07/97	7.1.2.3- A302	Spectral response curve of AVHRR channel 3A contains relative response points less than 80% between the 80% points. The dip lies just below the 80% spec limit at approximately 74%. This feature is consistent with the spectral response curve of the channel 3A filter, and is located at the long wavelength side of the pass band.
W-90	1522	01/16/98	7.1.2.5, 7.1.2.6- A301	A301 Channel 4 spectral response fails LW 50% wavelength and in-band dip <80%. Spec: LW 50% = 11.3 + .09/-.13μm; Actual: LW 50% = 11.43μm. Spec: No response dips <80% between 80% response points; Actual: dip <80%. A301 Channel 5 spectral response fails LW slope requirement. Spec≤4.0%; Actual = 5.2%.
N/A	1561	08/06/98	3.2.6- A305, A306, A307 - A308	Waive having the contractor perform the life test on AVHRR Brushless DC Motor. Test will be conducted at GSFC.
W-102	1568	08/06/98	5.6.4.1b A304	Failure to meet the ±100mV variation requirement at endpoint of Channel 4 for baseplate temperatures of 10°C and 20°C. Current lot of EG&G Judson detectors have several Channel 4 detectors that exhibit high detector junction resistance and low cutoff wavelength. One of these detectors is currently in the A304 instrument. These detectors exhibit a large nonlinear response that causes a larger than typical reduction in responsivity as the baseplate temperature varies from 10°C to 20°C.
W-113	1644	09/23/99	5.7.2.3 A301	The .9984 Mhz clock phase is 180 deg. out of phase in relation to the 40 Khz sample pulse. This was corrected for all instruments A302 on up. A301 has passed all acceptance test with the spacecraft.
W-114	1648	09/23/99	5.6.3.1a A301	Channel 1 endpoint is 6.21 volts and channel 2 endpoint is 6.28 volts for a scene albedo of 1.00 (requirement is 6.05 +/-0.15 volts).
W-111	1649	09/23/99	5.6.4.1b A301	Channel 5 endpoint saturates for a 335.0 K ECT and 15C baseplate. Requirement is 300+/-100 mV for 335.0 K ECT. A301 Channel 5 saturates for scene temperatures that exceed 333.9 K for a 15C baseplate temperature. The Ch 5 scene saturation temperature rises to 334.4 for a 20C baseplete temperature. Over mission life, orbital data shows that ch4/5 scene saturation temperatures increase.
N/A	1653	11/04/99	5.15.3-3, 5/15/3-4, 5.15.3-9 - A302	AVHRR A302 did not meet the contractual requirements for electrical transients and current ripple.
W-115	1682	04/04/00	5.15.3.8, 5.15.3.4, 5.15.3.9 - A301	Waive A301 conducted emissions requirements as defined in the AVHRR Performance Spec S-480-81, sections 5.15.3.8, 5.15.3.4, and 5.15.3.9 and UIIS IS-20029950 section 3.1.3.5.4.
W-103B	1570B	07/28/00	5.18 A304	AVHRR channels 1,2, and 3A have susceptibility to +10V/-12v 10usec pulses injected onto the +28V main bus. The level of susceptibility in terms of peak amplitude noise given in the attached table to CCR require waiver as defined in the AVHRR Performance Specification, AVHRR UIIS, and GIIS.
W-102A	1753	07/28/00	5.6.4.1b A304	Ch4 on the A03 does not meet the +/-100mV endpoint variation requirement. Current endpoint variations from 15C measure -154.2mV (at 10C) and +82.3mV (at 20C).

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W-141	1761	09/05/00	5.16.3 A304	Increase the limit on Mates/Demates for A304 from 30 to 50. A304 has had 38 to 40 mate/demate cycles on the flight connectors (J1 through J6) since it was originally built. The large number of mates and demates is directly related to issues with VIS to IR registration, vibration testing and shipments to LMMS for spacecraft testing. The limit is requested to be increased to 50 to allow for additional mates/demates prior to launch without revising this waiver. The 50 mates are consistent with the waiver (W86) for A302.
W-140A	1852	08/13/01	NAS5300.4 (3M)	This waives the requirement to be certified when reworking specific OSCE surface mount components. A workaround to use internal ITT Standards with NASA on-site oversight was adopted and approved at the time by the NASA SAM.
W-145	1853	08/13/01	5.16.3 A306	J7 has 36.5 mate/demate cycles and J1 through J6 has 28.5 cycles. The increase to 50 will allow additional mates at the spacecraft.
W-144	1858	09/28/01	5.15.3.4 A306	These conducted emissions are typical for the AVHRR instrument. The same requirement in the UIIS, paragraph 3.1.3.7, is <5% of the steady state current. This is 47.2 mA and is met by the measured value on A306.
W-150	1903	03/15/02	5.16.3 A303	Waive the mate/demate cycle requirement from 30 to 60.
W152	1907	03/13/02	5.15.3.4 A303	Current ripple on the 28 V Main Bus is 35.8 mA versus a spec of 19 mA.
W-153	1908	03/15/02	A303 5.15.3.9	Waive the following three conducted emissions turn on transient requirements for the A303. 1. Performance Spec paragraph 5.15.3.9 and UIS Paragraph 3.1.3.2.4 both requiring that the motor turn on load current overshoot transient shall not exceed 1A. The measured overshoot transient was 1.05A. 2. Performance Spec paragraph 5.15.3.9 cooler heat turn on load current overshoot transient shall not exceed 3.3A. This was measured at 3.58 A. 3. Performance Spec paragraph 5.15.3.9 requires the duration of the cooler heat turn on transient to be less than 2 ms. The turn on transient duration was measured at 9.7 ms.
W-148	1875	12/12/01	A306	Waive the following conducted emissions requirements: 1. Motor Turn-on transient amplitude: spec para 5.14.3.9 and UISS para 3.1.3.2.4 req. is less than 1 A, overshoot was 1.3A. 2. Coolder Heat Turn-on Transient amplitude: spec para 5.15.3.9 req. is less than 3.3A, measured at 3.5A. 3. Coolder Heat turn-on transient duration: spec para 5.15.3.9 requires the duration to be less than 2mS. Measure at 9.4mS.
W-149	1888	02/04/02	A308	Waive the Channel 1 Spectral Response req. of AVHRR Performance Spec para 7.1.2.1-5 which requires that the channel 1 spectral response be less than 0.02 micrometers between the 50% and 80% points. The measured response between the 50% and 80% points was 0.026 micrometers.

Deviation/ Waiver No.	CCR No.	CCR Approved Date	Section/ Effectivity	Description
W-155	1928	06/21/02	A307	Waive the 2% or 19 mA, req. for the steady state load current ripple on the 28V Main Bus of paragraph 5.15.3.4. The measured value was 38 mA.
W-156	1929	07/22/02	A307	Waive the following requirements defined in para 5.15.3.9. Moto turn on transient measured 1.3A vs a spec of 1A. Cooler heat transient measure 3.8 mA vs a spec of 3.3A. The duration of this transient was 9ms vs a spec of 2 ms.
W-161	1981	04/02/03	A305: 1. 5.15.3.9 2. 5.15.3.9 3. 5.15.3.9	1.Waive the motor turn-on transient amplitude requirement of 1A. Measured value was 1.06 A. 2.Waive the Motor turn-on transient duration requirement not to exceed 1 sec. Measured duration was 7.88 sec. 3.Waive the Cooler Heat turn-on transient duration requirement of less than 2 ms. Measured duration was 10.8 ms.